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Flight Standards Service
Engineering and Manufacturing Division
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STATISTICAL PRESENTATION OF OPERATIONAL LANDING PARAMETERS FOR TRANSPORT JET AIRPLANES

[redacted]

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PREFACE

For many years, the type certification requirements have treated the establishment of landing distances in a highly empirical manner. The preamble to Special Civil Air Regulations, SR-422, specifically stated that long range studies on the rationalization of this stage of airplane performance have not yet produced any satisfactory results.

Prior to any rationalization of the landing distance requirement, it would be necessary to review and analyze the typical scheduled air carrier performance in the landing regime. To this end, the Flight Test Branch of the Federal Aviation Agency performed a phototheodolite survey of turbine powered landing operations at four airports considered representative of the range of normal operations in the U. S. A.

The analysis and results of this survey are contained herein in a form adaptable for formulation of an approach to a rationalized landing distance requirement.

ABSTRACT

This report contains the results of phototheodolite data accumulated on 183 daylight landing operations of scheduled air carriers flying the Boeing 707, 707B, 720, 720B, Convair CV-880, and Douglas DC-8 jet airplane models. These measurements were obtained during the months of June and July 1961 at Chicago O'Hare Airport, San Francisco International Airport, Denver Stapelton Airport, and Dallas Love Field.

The parameters included in this report are the approach angle, distance to threshold of the fifty-feet-height point, the flare-point height and distance to threshold, the threshold height and speed, the main gear touchdown speed and distance from threshold, the speed bleedoff from threshold to touchdown, the nose gear down-time after main gear touchdown, and the spoilers up-time after main gear touchdown.

These parameters are statistically presented in the form of relative frequency distributions (histograms), cumulative frequency distributions (probability curves), and as probability distributions in two dimensions (curves of equal probability). The calculated values of arithmetic mean, standard deviation, skewness and kurtosis factors are shown in tabular form and on the actual curves.

SYMBOLS

V_s	Stall Speed, knots (CAS)
V_{th}	Threshold Speed, knots (CAS)
V_{th}/V_s	Threshold Speed Ratio
V_{td}	Touchdown Speed, knots (CAS)
V_{td}/V_s	Touchdown Speed Ratio
V_B	Bleedoff speed, knots (CAS) $= V_{th} - V_{td}$
V_B/V_s	Bleedoff Speed Ratio
S_F	Flare-point distance to threshold, feet (Distance necessary to reach threshold.)
S_{50}	50-foot height point distance to threshold, feet (Distance necessary to reach threshold)
S_{MG}	Main gear touchdown distance from threshold, feet
H_F	Flare-point height, feet
H_{th}	Threshold height, feet
$H_{th}/50$	Threshold height ratio
t_{NW}	Nosewheel down time from touchdown, seconds
t_{sp}	Spoilers up time from touchdown, seconds
θ	Approach angle, degrees
$\theta/3.0$	Approach angle ratio
N	Number of observations in sample
$\bar{X}$	Arithmetic mean value of sample
σ	Standard deviation of sample distribution
α_3	Skewness factor of sample distribution
$(\alpha_3)'$	Skewness factor of population

(CONT'D)

α_4	Kurtosis factor of sample distribution
$(\alpha_4)'$	Kurtosis factor of population
M	Mode, or location of highest point of mathematical model
P	Probability
f	Frequency
W	Landing weight in pounds

SOURCE AND ACCURACY OF DATA

The various parameters contained in this report were obtained from the analysis of phototheodolite records obtained with a modified Bell and Howell Filmo D-70A 16 mm motion picture camera. A complete description of this apparatus can be found in reference (5).

The phototheodolite film provides a continuous space-time relationship from which an average velocity-distance point is derived for each second duration of the landing operation. These data points are then plotted and a velocity curve established by visually fitting a curve to the points. This visual method is considered adequate since it is felt that any error introduced is within the error of the sample itself.

The overall accuracy of this method is estimated to be ± 3 knots in speed, ± 2 feet in height, ± 10 feet in distance, and ± 0.01 seconds in time including instrument, reading, and human error.

Reference stall speeds were obtained from approved airplane flight manuals utilizing the aircraft's actual landing weights as furnished by the airlines.

PRESENTATION AND ANALYSIS OF DATA

The relationships that have been established are, in general, straightforward and need no explanation. For this analysis, the landing requirements as set forth in Special Civil Air Regulation SR-422B has been used as the foundation around which the study has been devoted. The specific portion of the landing requirement, section 4T.122, are repeated herein for continuity:

a. The landing distance shall be the horizontal distance required to land and to come to a complete stop from a point at a height of 50 feet above the landing surface

b. The landing shall be preceeded by a steady gliding approach down to the 50-foot height with a calibrated airspeed of not less than $1.3V_s$

To further define the steady gliding approach, an angle of three degrees has been used as the one most often considered in any attempt to establish a quantitative approach to the landing requirement. Additionally, the 50-foot height and the flare height have been set forth so that a visual comparison can be made between the operational landing and the type certification landing. In all cases, the approach angle set forth is that which occurred just prior to the flare-point in the flightpath. The flare height and the flare distance to the threshold were determined by the point at which the flightpath departed from the straight line plot of the airplane height versus ground distance. It is emphasized here that this point represents the reaction of the airplane and not the initiation of the flare action by the pilot.

Finally, the speed bleed off between threshold and touchdown has been established on the realization that any rationalized landing procedure may require a definition of the speed loss from threshold to touchdown as well as the touchdown distance to insure the most reproducible type landing. All speeds presented are calibrated airspeeds obtained by correcting the ground speed of the airplane by the applicable wind component and density ratio. The lack of data on ground effect and the dynamic effect of the airplane maneuver precluded use of indicated airspeed.

The landing parameters for each individual landing are given in Tables I through IV at the end of this report. These data were grouped into appropriate class intervals of equal width in the form of grouped frequency distributions. Careful attention was given to grouping the observed data so that class boundaries covered the whole range of the observed values without gap or overlap, whereever possible. The arithmetic mean ($\bar{X}$), standard deviation (σ), asymmetry or skewness factor (α_3), and flatness

or kurtosis factor (α_4), were determined for each distribution using methods of moments outlined in reference (1). The coefficients are tabulated in the summary table for all aircraft and airports combined together. The data are also summarized as relative frequency distributions (histograms), and cumulative frequency distributions (probability curves). The relative frequency distributions pictorially show the shape of the distribution, while the cumulative frequency plots on semi-log paper show the probability of exceeding or not exceeding a given value of the parameter. The figure numbers for the graphical presentation of each parameter are indexed in the summary table.

Since it is expected that most pilots will endeavor to make relatively consistent approaches and landings, deviations around certain speeds and heights are expected to be normally distributed. Accordingly, tests for normality were applied to each distribution by calculating the 95 percent confidence limits of these population parameters on the basis of a sample skewness and kurtosis, using criteria of reference (2).

The 95 percent confidence limits of the population parameter can be determined on the basis of a single sample and would indicate an interval that will include the value of the population parameter 95 percent of the time, i.e., the probability associated with the given interval is (0.95) before the sample is drawn.

The 95 percent confidence limits for skewness and kurtosis are as follows:

$$P\left\{\left[0 - 1.96\sqrt{6/N}\right] \leq (\alpha_3)' \leq \left[0 + 1.96\sqrt{6/N}\right]\right\} = 0.95$$

$$P\left\{\left[3 - 1.96\sqrt{24/N}\right] \leq (\alpha_4)' \leq \left[3 + 1.96\sqrt{24/N}\right]\right\} = 0.95$$

The above expressions correspond to approximately the 95 percent probability level; that is, if an unbiased sample were drawn from a normal population, the value of the skewness factor (α_3) and the kurtosis factor (α_4) for the sample could have any value within the above limits in 95 out of 100 times a sample of size (N) was drawn from that normal population.

The foregoing tests were applied and the normal curve was fitted to the data in each case when the skewness factor was within the limits for normality or symmetry. If the skewness factor indicated significant skewness, the Pearson Type III curve was fitted. Generally, when the confidence limit for the skewness factor indicates symmetry or normality, the confidence limit for the kurtosis factor also indicates normality.

However, for the threshold speed ratio, the confidence limits were so marginal that both the normal and Pearson Type III curves were fitted for completeness of presentation. For clarity, the type of curve fitted is noted for each probability curve.

In addition to plotting the probability distributions for each parameter independently, bivariate probability envelopes have been drawn for flare-point height versus flare-point distance to threshold, and bleed-off speed versus touchdown distance from threshold, and the envelopes were fitted around the mean values. The curves are fitted to the data by methods outlined in reference (3). This reference, however, only treates the joint probability of two normally distributed variables. When the tests for normality show the skewness factor to be greater than the confidence limit, the basic method is applied to the skewly distributed variables by transforming from the skewed function to the normal function, using the method of reference (2) and the area tables for the normal and Pearson Type III curves given in reference (4). The values of (P) for each curve in figures 25 and 26 indicate the probability that a combined value of the two variables will be outside the envelope curve.

DISCUSSION

SAMPLE SIZE

In any statistical investigation of the type being presented, there always exists some doubt as to the adequacy of the sample size. This analysis of sample size was based on available information of the mean and standard deviation of the population that could be expected at each individual airport. Although this available information is not considered precise, an approximation of an acceptable sample size can be obtained from the known statistics.

The following is based on the standard deviation of an approach angle ratio obtained from a previous sample of 27 observations performed as a trial run. The mean ($\bar{X}_{TR}$) and the standard deviation (σ_{TR}) were determined to be 0.92 and 0.20 respectively.

The adequacy of a sample size of 53 observations at Chicago, 57 observations at San Francisco, 40 observations at Denver, and 33 observations at Dallas was determined using method of reference (7).

The trial run value of mean (0.92) was taken as the estimate of the most desirable value of mean ($\bar{X}_D$) of each of four available samples. Then for the probability level of 0.95, and 'fiducial limits' ($L = \bar{X}_{TR} - \bar{X}_D$) at (±0.08) units from the sample mean, the required sample size was determined to be:

$$N_R = (t)^2 (\sigma_{TR})^2 / (L)^2$$

$$= (1.96)^2 (0.20)^2 / (0.08)^2$$

$$= 24 \text{ observations}$$

The above indicates that since the individual sample sizes at four different airports are adequate for 0.95 probability level, the combined sample of 183 observations is also adequate.

STATISTICAL DISTRIBUTIONS

Examination of the values of statistical parameters (α_3) and (α_4) given in Summary Table, and application of statistical tests of normality indicated, that for three (figures 3, 11, and 15) of the twelve distributions, the values did not depart significantly from what would be expected for normal distributions; namely, ($\alpha_3 = 0$) and ($\alpha_4 = 3$). On the basis of foregoing considerations, normal probability distributions were fitted to the data for 50-foot height point distance to threshold, threshold speed ratio, and touchdown speed ratio.

In fitting the normal curve, it was assumed that only chance errors were present and that the arithmetic mean represented the best approximation of the true value of mean of universe. The normal curve is only one of a number of kinds of curves which may be fitted to a relative frequency distribution. It should, in no sense, be thought of as a form having general applicability to all distributions. The suitability of the normal curve for any particular relative frequency distribution can be established by using the guides set forth in reference (8). Those guides indicated that the data for threshold speed ratio (figure 11) was on the border line between the symmetrical and asymmetrical distributions. This data evantually was also treated as the skewed distribution.

ASYMMETRICAL DISTRIBUTIONS

The problem of fitting the mathematical model curve to the experimental data becomes more complicated if the relative frequency distribution is not symmetrical, but is skewed or asymmetrical. Examination of the values of the statistical parameters (α_3) and (α_4) given in Summary Table, and the application of statistical tests of normality indicated that for distributions other than given in figures 3, 11, and 15, the amount of skewness is significantly greater than what would be expected if the samples were from the normal universe or population. All of the relative frequency distributions have a positive skewness, i.e., they are skewed to the right.

There are a great many types of skewed theoretical curves which may be fitted to asymmetrical relative frequency distributions. Selection of any particular skewed theoretical curve depends upon the availability of computational facilities, desired degree of accuracy in fitting, and whether the cumulative frequency tables are readily available or not.

The distribution that could have been particularly useful in this analysis because it is convenient to deal with mathematically, is Gamma distribution as described in reference (6). The cumulative frequency distribution of this function is called the "Incomplete Gamma Function" and has been extensively tabulated by Karl Pearson. But such tables are not in common use, nor readily available.

Since Gamma distributions are essentially the same as Type III curves of Pearson, there appeared the tenable solution. The Pearson Type III distribution curves were used because they were compatible to the ideal distribution curves represented by Gamma function. Also, the Pearson III distribution curves form three-parameter family; i.e., the parameters for a particular distribution could be determined from the mean value, the standard deviation, and the coefficient of skewness of the distribution. In addition, the actual computations of these Pearson Type III curves was facilitated by the availability of cumulative frequency distribution tables given in reference (4).

PROBABILITY DISTRIBUTIONS

The results of the above consideration are presented as probability curves in figures enumerated in the Summary Table. The data points, shown on the probability curves, represent cumulative frequencies of observed quantities for the previously determined class interval.

The mathematical models were used to smooth out the irregularities in the observed data, to provide the systematic fairing of data, and to permit extrapolation. The purpose of extrapolation is to have some indication of the magnitude of various quantities likely to be equaled or exceeded in a greater number of landings than were actually observed.

Inspection of probability graphs indicates that the above assumption was valid, and the theoretical curves indicated a reliable representation.

The statistical sample was 183 landings. The contents of these 183 landing samples with regard to numbers of various airplane types appears neither pertinent nor significant as far as the results of this report are concerned. Such contents were given, however, as a matter of interest in the second column of Tables I through IV.

CONCLUSIONS

This report presents the results of a statistical approach to analyzing operational landing parameters. The principal conclusions as indicated by Figures 1 through 26 of Appendix "B" are:

(1) There is little correlation between the typical airline operation and the operation used to demonstrate landing distances during type certification.

(2) The mean operational approach angle is less than three degrees and the airplane is flared prior to crossing the threshold.

(3) The mean threshold speed is nine knots faster than the corresponding value used during type certification demonstrations.

(4) The mean threshold height is 30 feet lower than the corresponding value used in type certification.

(5) The mean touchdown distance is 1,510 feet from the threshold with the range of touchdown distances extending from 220 to 4,710 feet from the threshold.

(6) The mean touchdown speed is equal to the threshold speed set forth in the type certification requirements.

(7) The mean nosewheel down time occurs three and six-tenths seconds after main gear touchdown, with spoilers up-time occurring two and one-tenth seconds later.

(8) As indicated by the bivariate probability envelope, there is no significant correlation between the flare-point height and flare-point distance to threshold, and between the speed bleed-off and the touchdown distance.

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APPENDIX A

SUMMARY TABLE

SUMMARY TABLE

Histogram Figure No.	Probability Figure No.	Symbol	Parameter	No. of Landings	Arithmetic Mean	Standard Deviation	Skewness	Kurtosis	Mode
1	2	$\theta/3^{\circ}$	Approach Angle Ratio	183	0.939	0.240	0.591	3.385	0.868
3	4	S_{50}	50-Feet-Height Distance to Threshold	183	755.0 Ft.	339.0 Ft.	0.282	3.202	707.0 Ft.
5	6	S_F	Flare Point Distance to Threshold	183	330.0 Ft.	409.0 Ft.	0.610	3.108	205.0 Ft.
7	8	H_F	Flare Point Height	183	32.0 Ft.	15.1 Ft.	0.916	3.884	25.1 Ft.
9	10	$H_{th}/50$	Threshold Height Ratio	183	0.399	0.200	0.773	3.869	0.322
11	12a, 12b	V_{th}/V_s	Threshold Speed Ratio	177	1.390	0.085	0.358	3.219	1.374
13	14	S_M	Main Gear Touchdown Distance from Threshold	183	1,514.0 Ft.	593.0 Ft.	0.632	4.902	1,327.0 Ft.
15	16	V_{td}/V_s	Touchdown Speed Ratio	177	1.300	0.072	-0.261	2.565	1.309
17	18	V_B	Bleedoff Speed	183	8.63 Kts	5.07 Kts	0.831	3.815	6.53 Kts.
19	20	V_B/V_s	Bleedoff Speed Ratio	177	0.089	0.052	0.831	3.737	0.067
21	22	t_{NW}	Nose Wheel Down Time from Touchdown	111	3.59 Sec	1.95 Sec	0.779	3.031	2.83 Sec.
23	24	t_{sp}	Spoilers Up Time from Touchdown	28	5.71 Sec	2.43 Sec	0.483	2.102	5.13 Sec.
—	--	---	<u>PROBABILITY ENVELOPES OF COMBINED VALUES OF:</u>						
—	25	—	a. Flare Point Height	183	32.0 Ft.	15.1 Ft.	0.916	—	—
			Flare Point Distance to Threshold	183	330.0 Ft.	409.0 Ft.	0.610	—	—
—	26	—	b. Bleedoff Speed	183	8.63 kts	5.07 Kts	0.831	—	—
			Main Gear Touchdown Distance from Threshold	183	1,514.0 Ft.	593.0 Ft.	0.632	—	—

APPENDIX B

FIGURES 1 THROUGH 26

FIGURE 1, FREQUENCY DISTRIBUTION OF APPROACH ANGLE RATIO

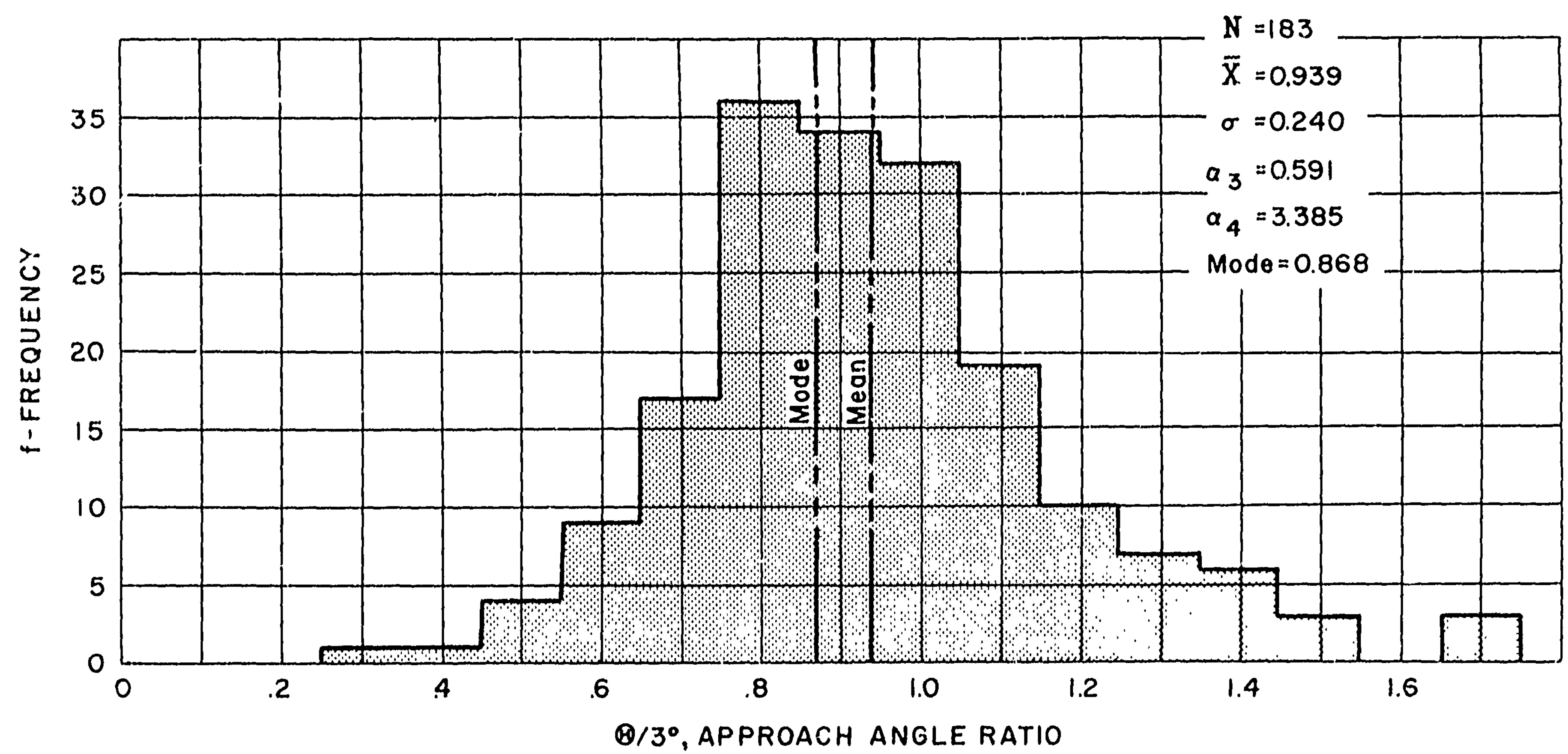


FIGURE 2, PROBABILITY OF EXCEEDING OR NOT EXCEEDING APPROACH ANGLE RATIO

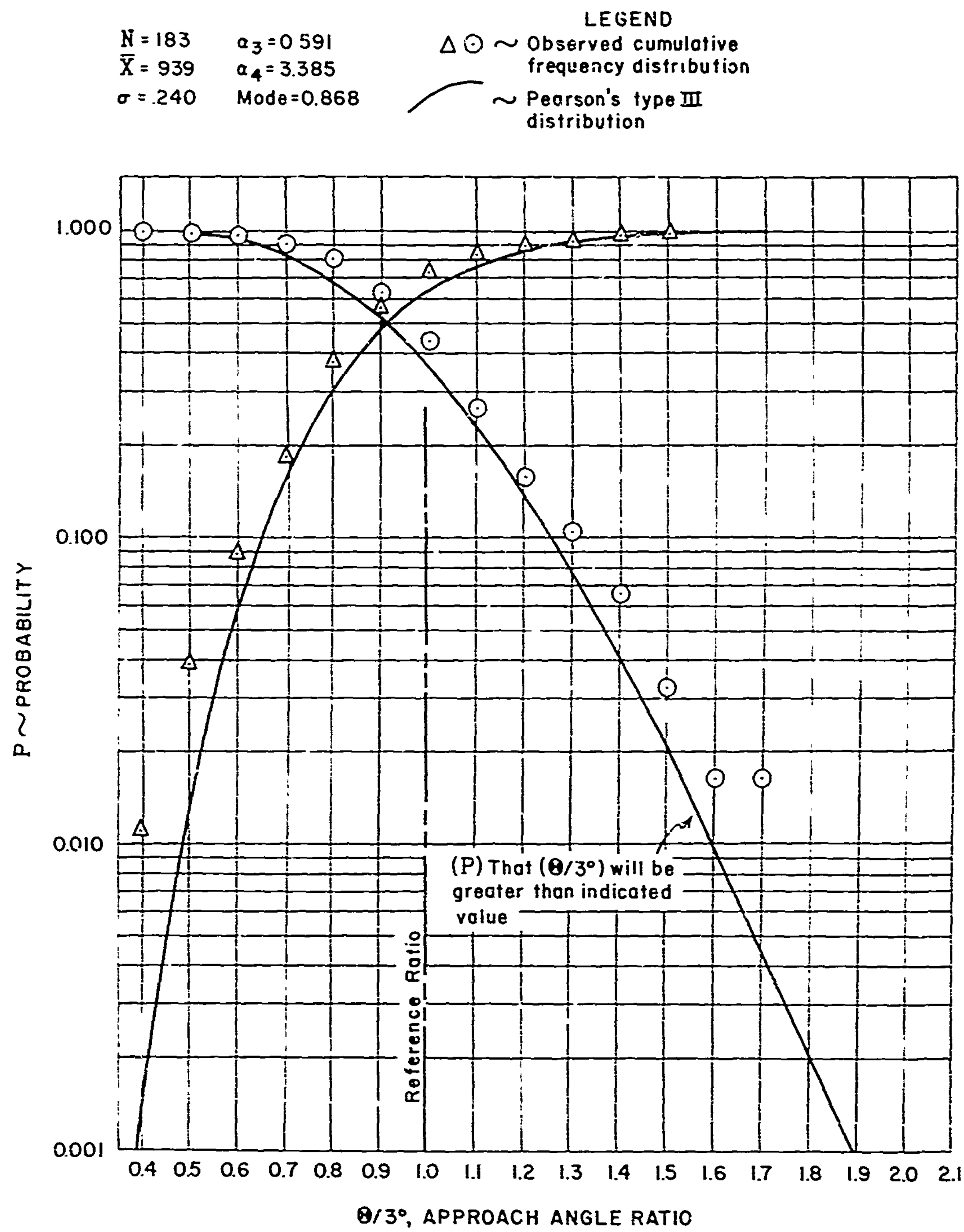


FIGURE 3, FREQUENCY DISTRIBUTION OF 50-FEET-HEIGHT DISTANCE TO THRESHOLD

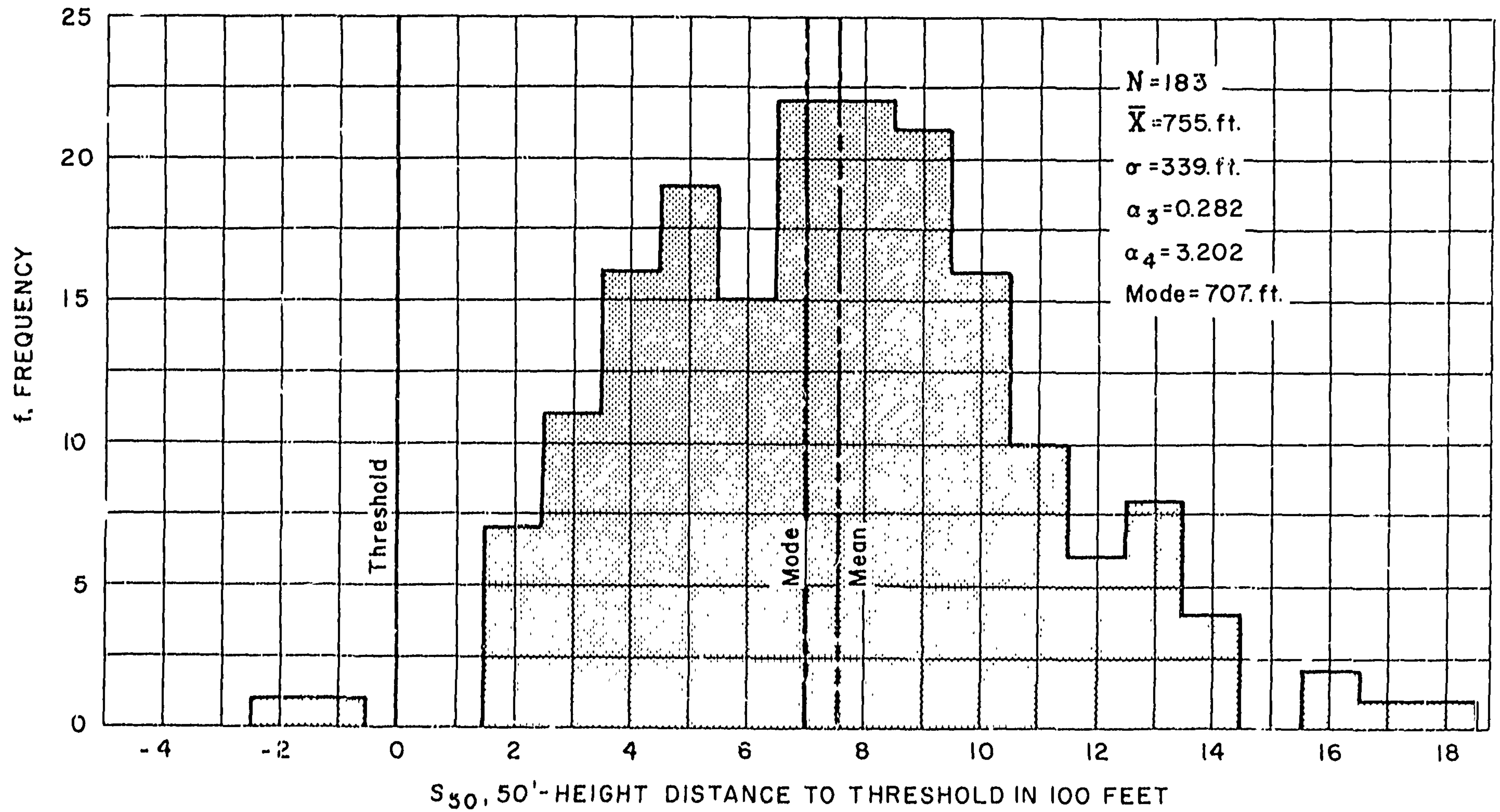


FIGURE 4, PROBABILITY OF EXCEEDING OR NOT EXCEEDING 50'-HEIGHT DISTANCE TO THRESHOLD

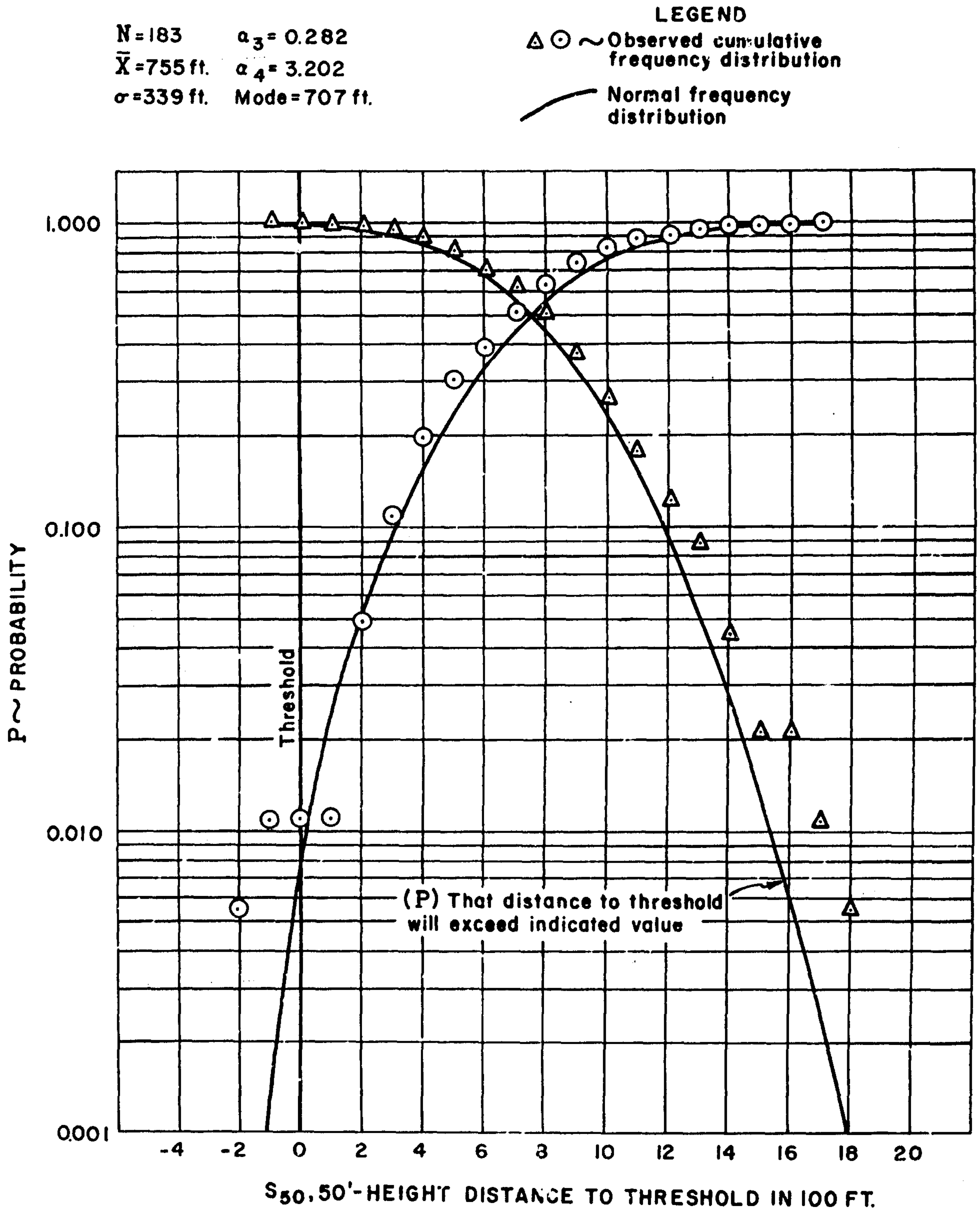


FIGURE 5, FREQUENCY DISTRIBUTION OF FLARE POINT DISTANCE TO THRESHOLD

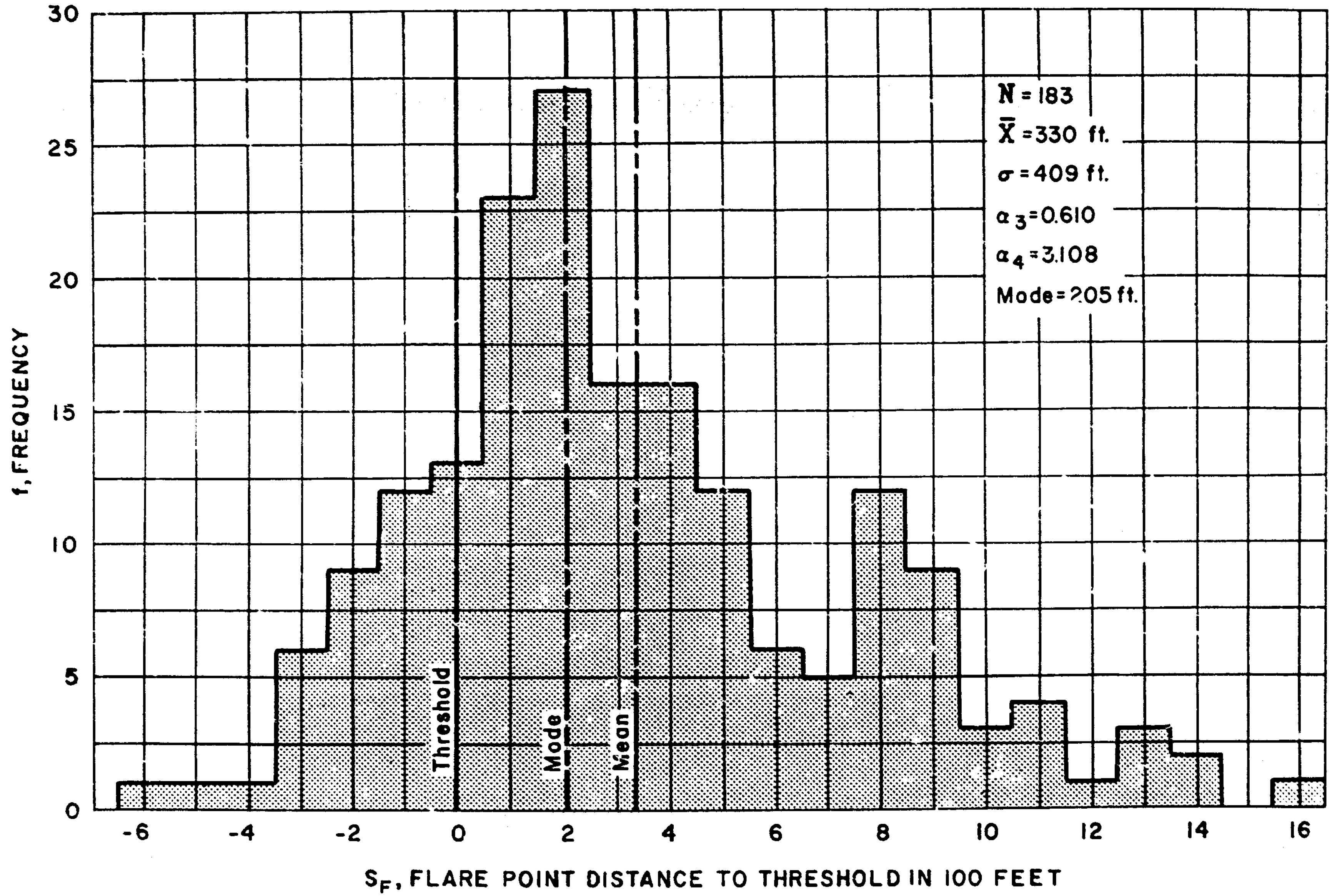


FIGURE 6, PROBABILITY OF EXCEEDING OR NOT EXCEEDING FLARE POINT DISTANCE TO THRESHOLD

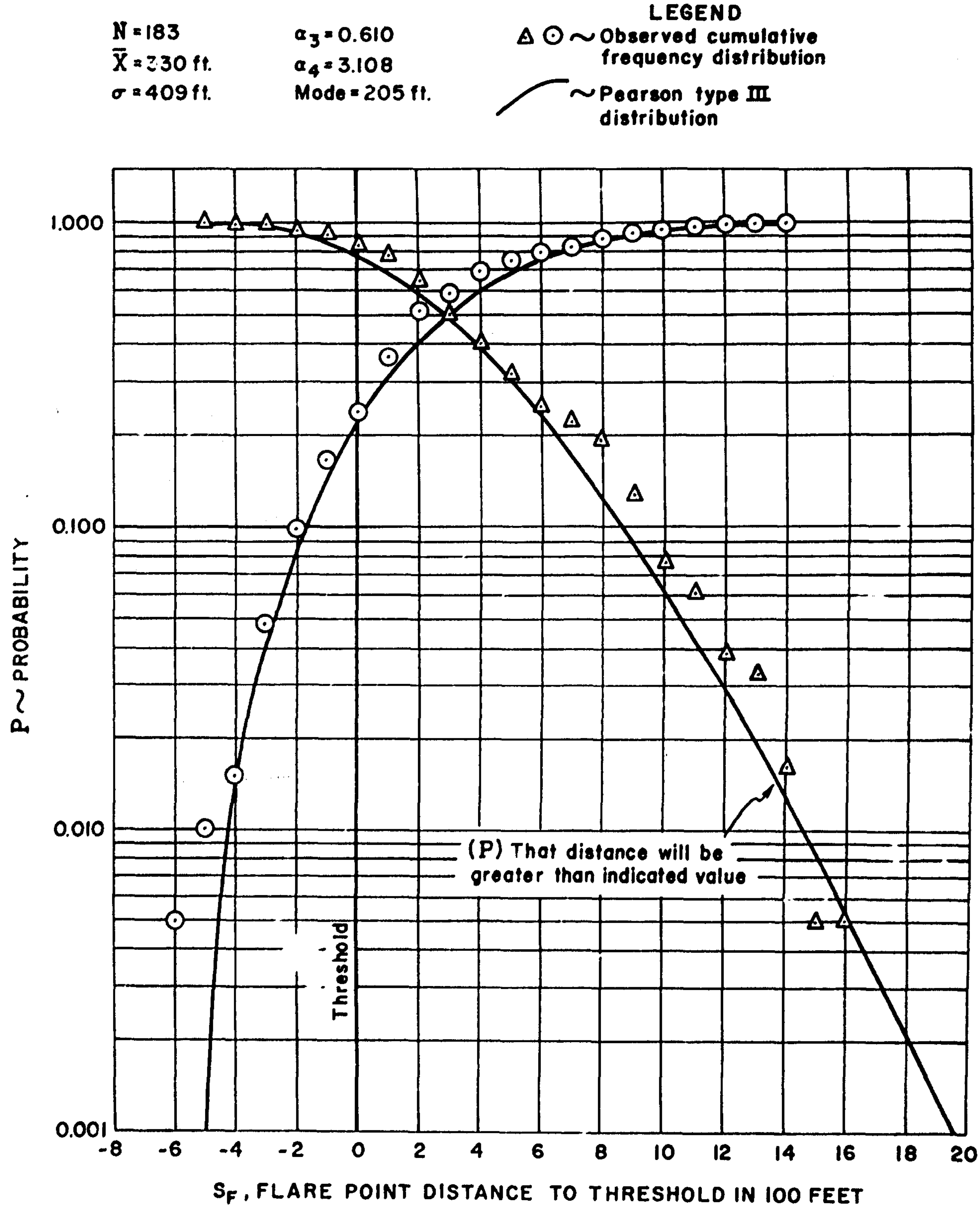


FIGURE 7, FREQUENCY DISTRIBUTION OF FLARE POINT HEIGHTS

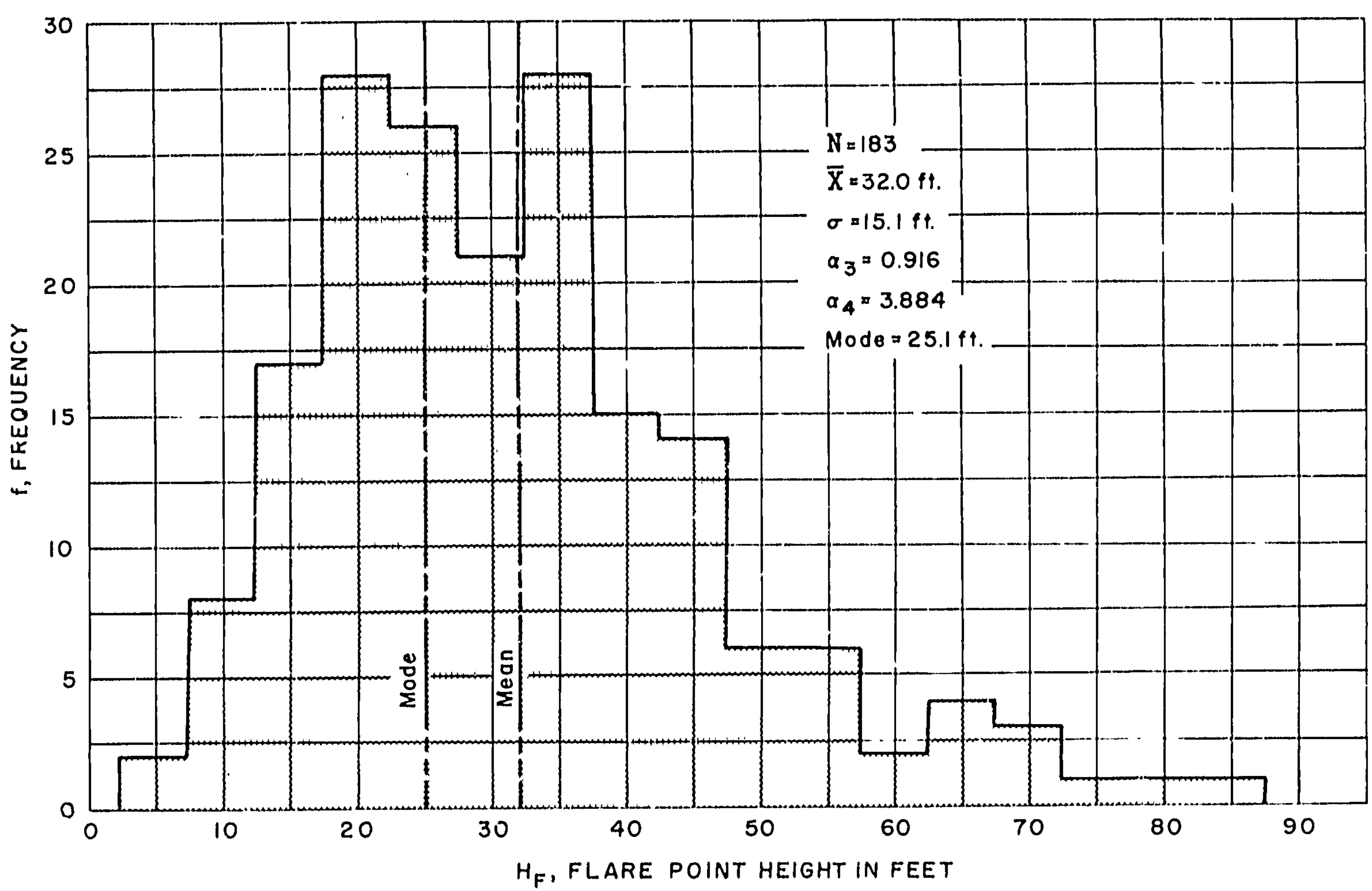


FIGURE 8, PROBABILITY OF EXCEEDING OR NOT EXCEEDING FLARE POINT HEIGHT

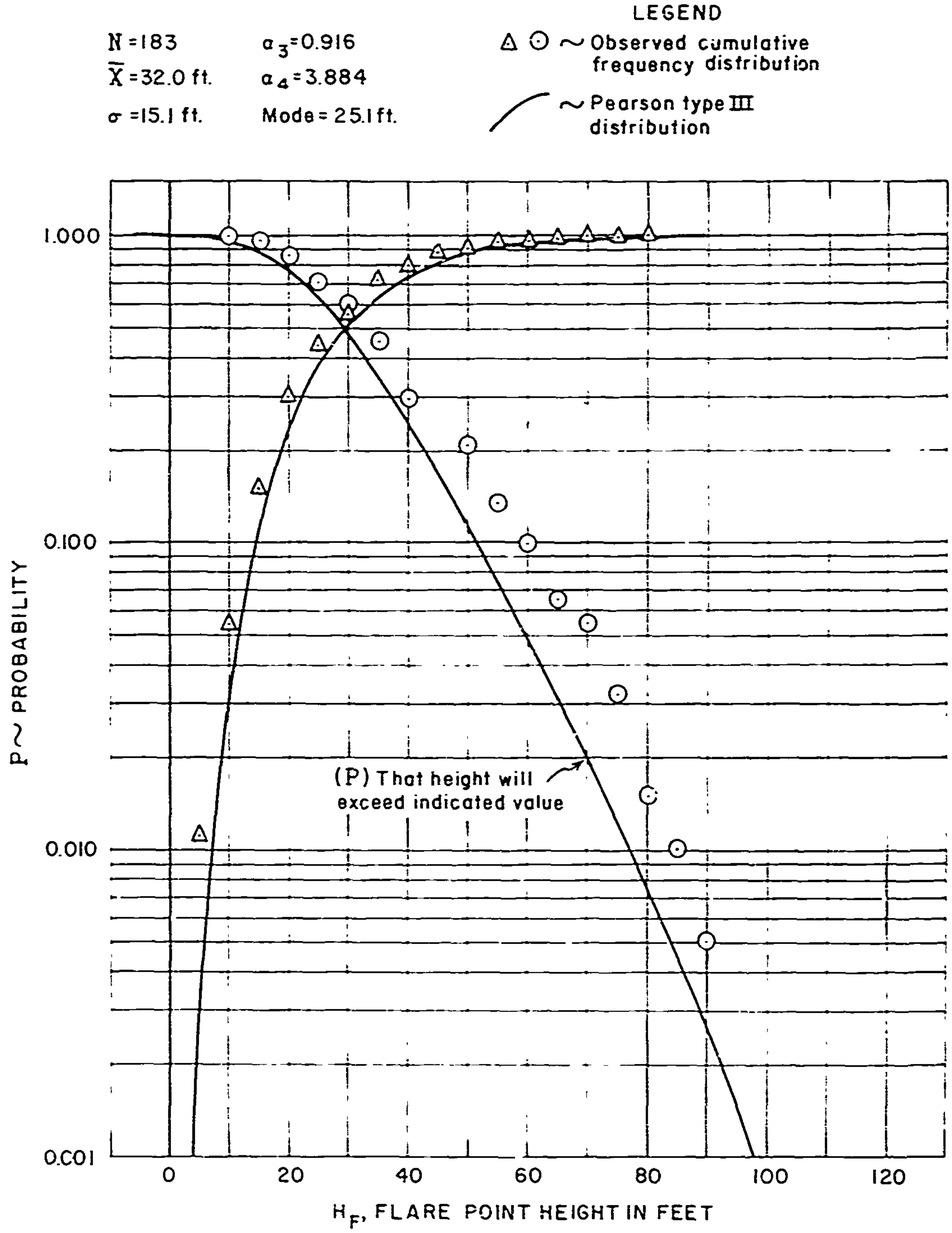


FIGURE 9, FREQUENCY DISTRIBUTION OF THRESHOLD HEIGHT RATIO

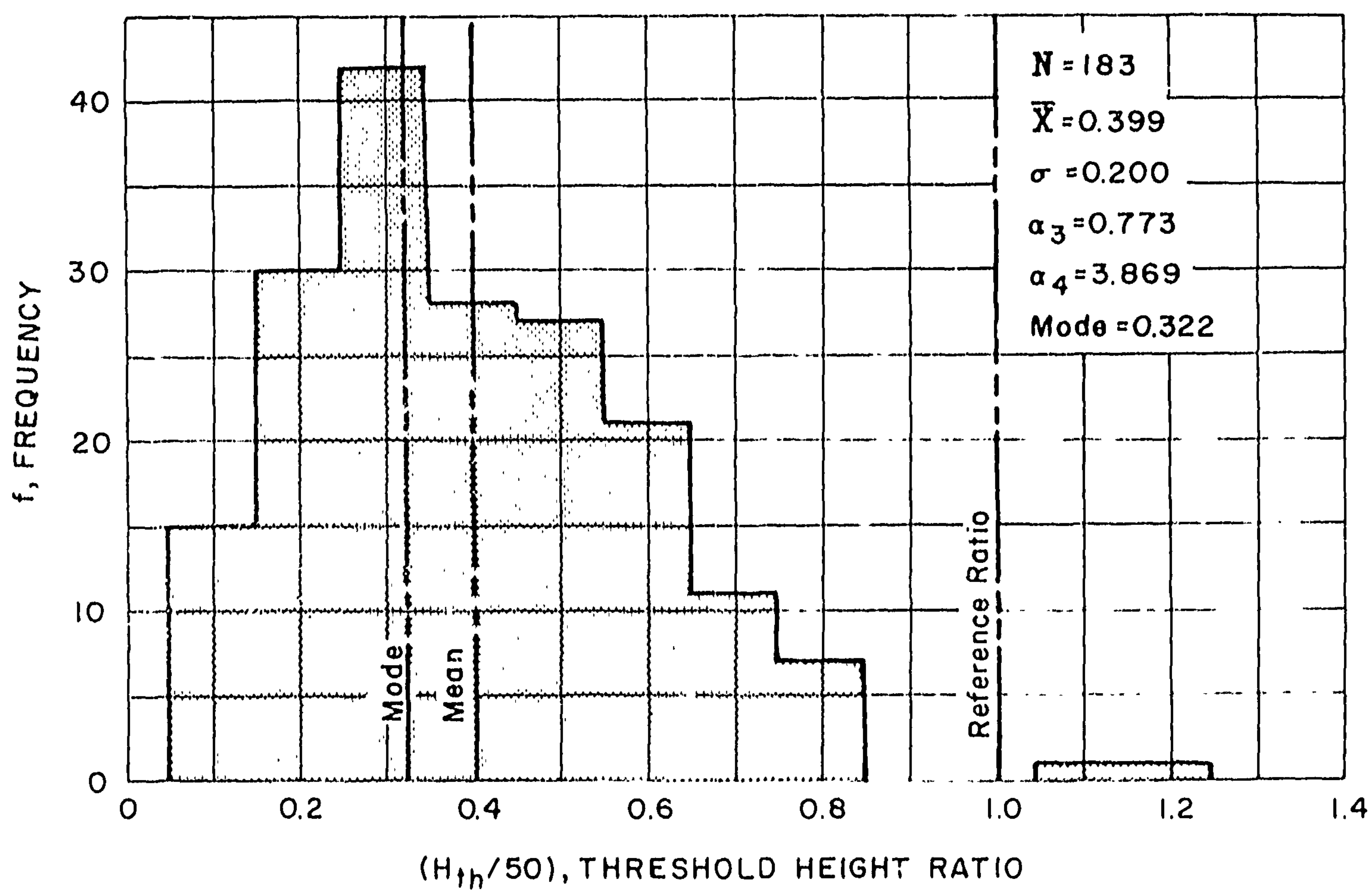


FIGURE 10, PROBABILITY DISTRIBUTION FOR THRESHOLD HEIGHT RATIO

$N = 183$ $\alpha_3 = 0.773$
$\bar{X} = 0.399$ $\alpha_4 = 3.869$
$\sigma = 0.200$ Mode = 0.322

LEGEND
△ ⊙ ~ Observed cumulative frequency distribution
~ Prearson type III distribution

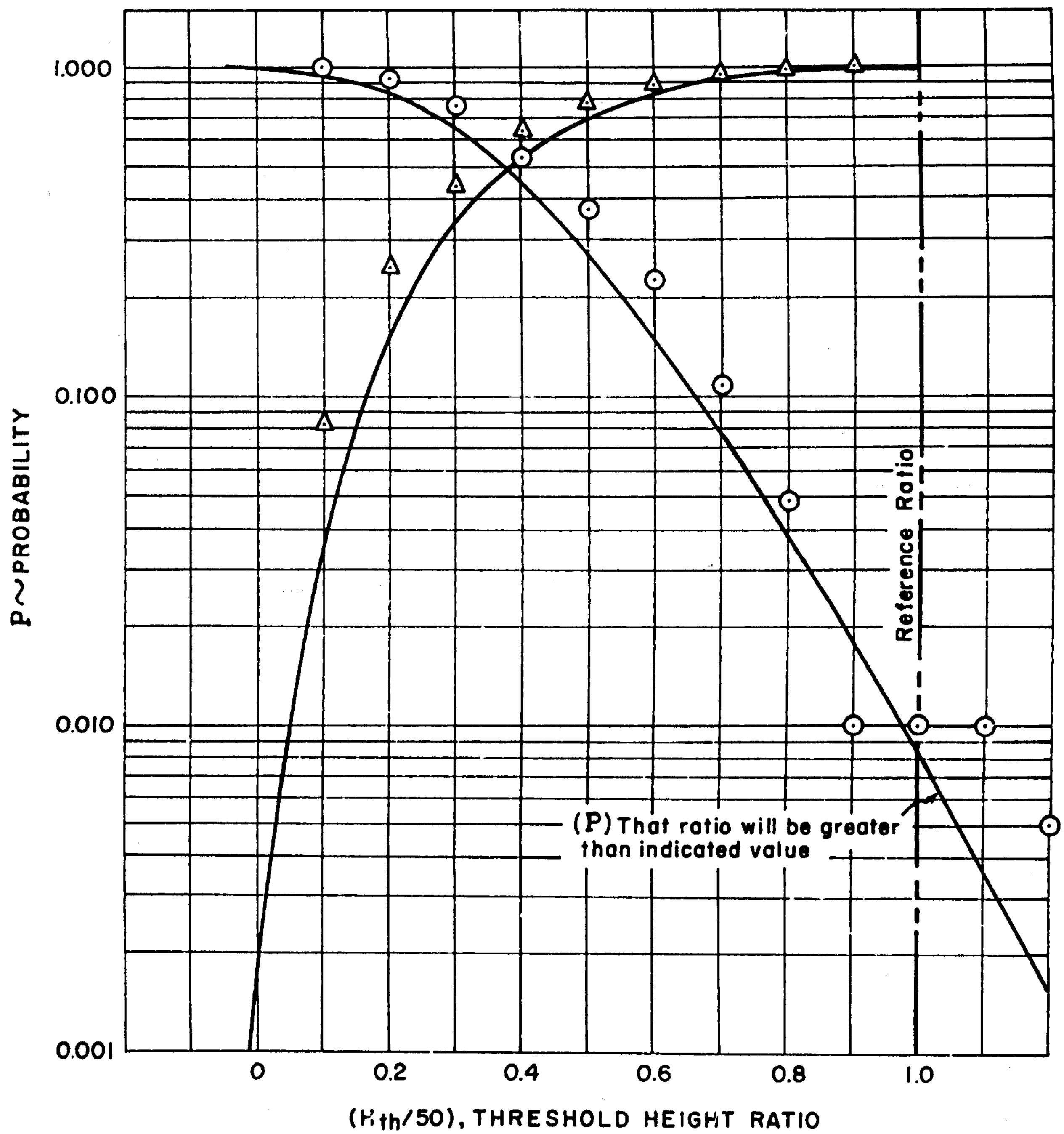


FIGURE II, FREQUENCY DISTRIBUTION OF THRESHOLD SPEED RATIO

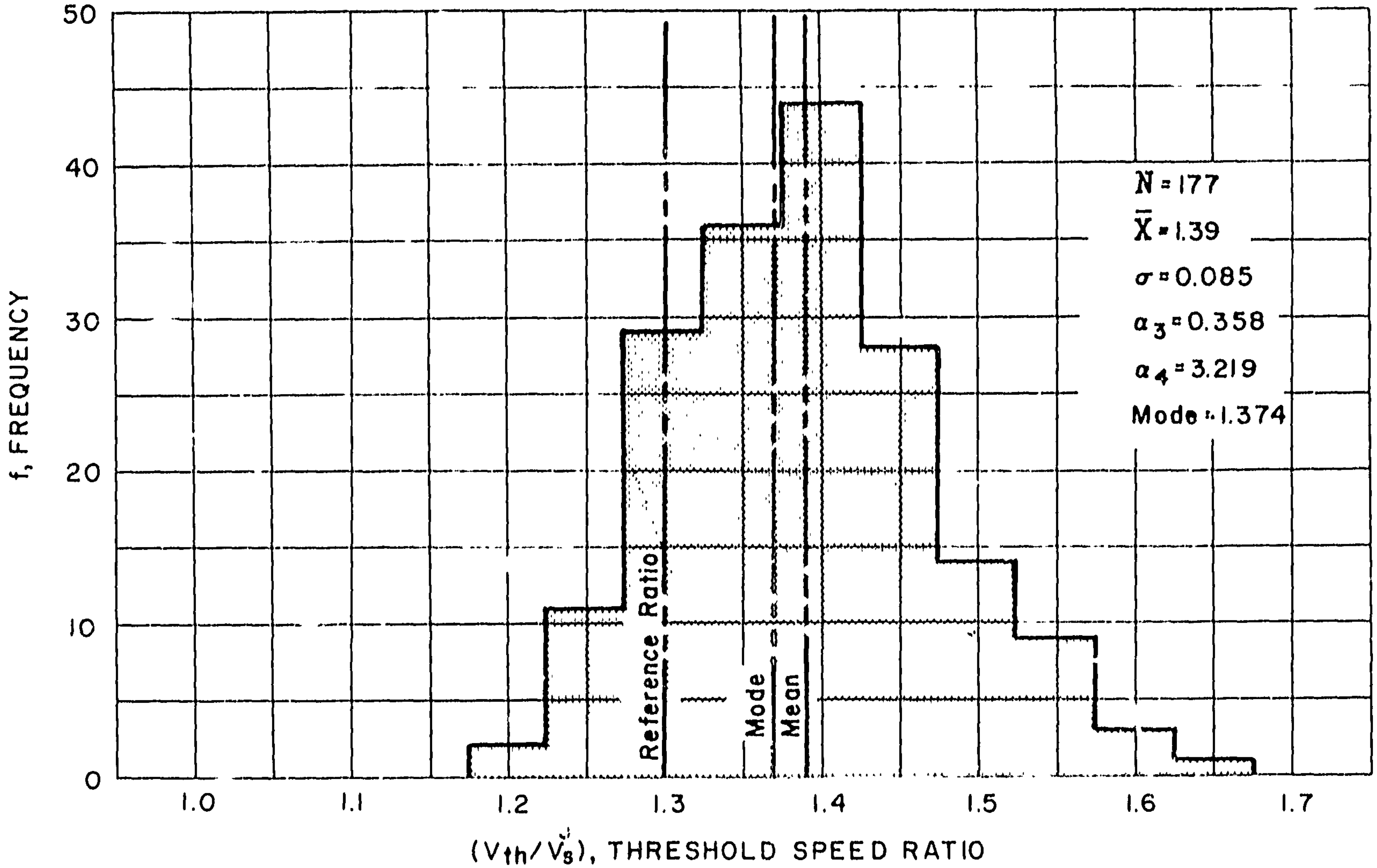


FIGURE 12 a, PROBABILITY OR EXCEEDING OR NOT EXCEEDING THRESHOLD SPEED RATIO

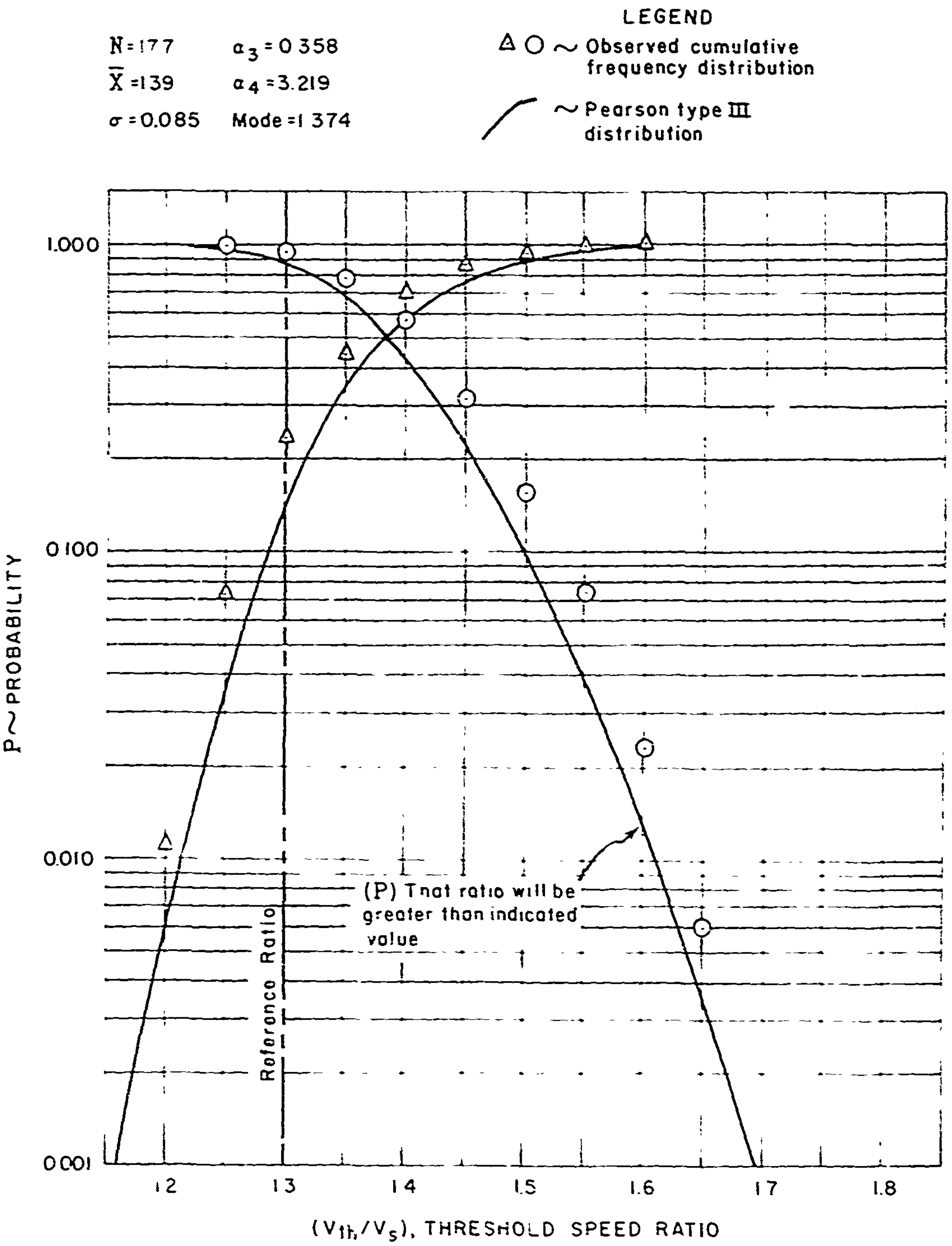


FIGURE 12 b, PROBABILITY OF EXCEEDING OR NOT EXCEEDING THRESHOLD SPEED RATIO V_{th}/V_s

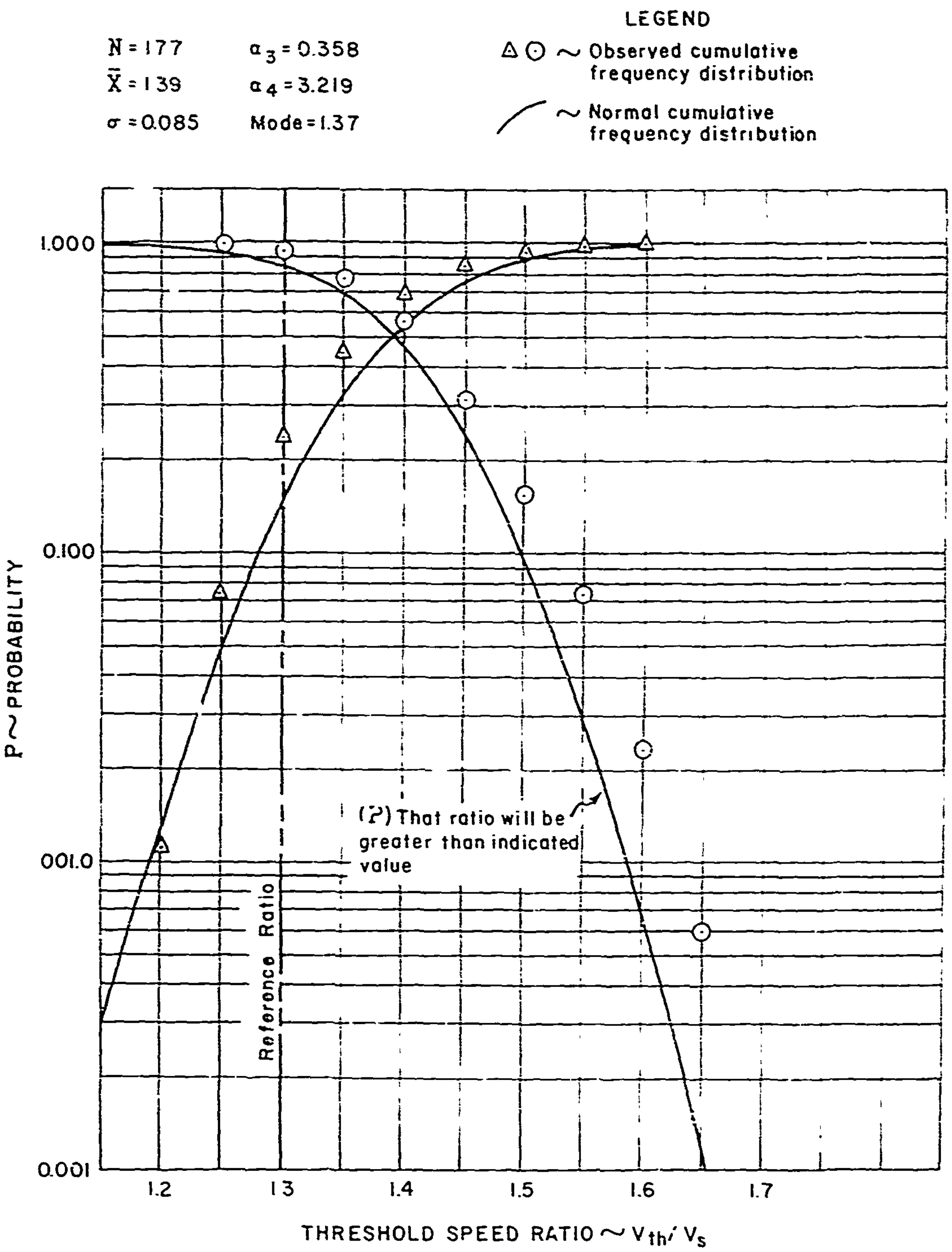


FIGURE 13, FREQUENCY DISTRIBUTION FOR MAIN GEAR TOUCHDOWN DISTANCE FROM THRESHOLD

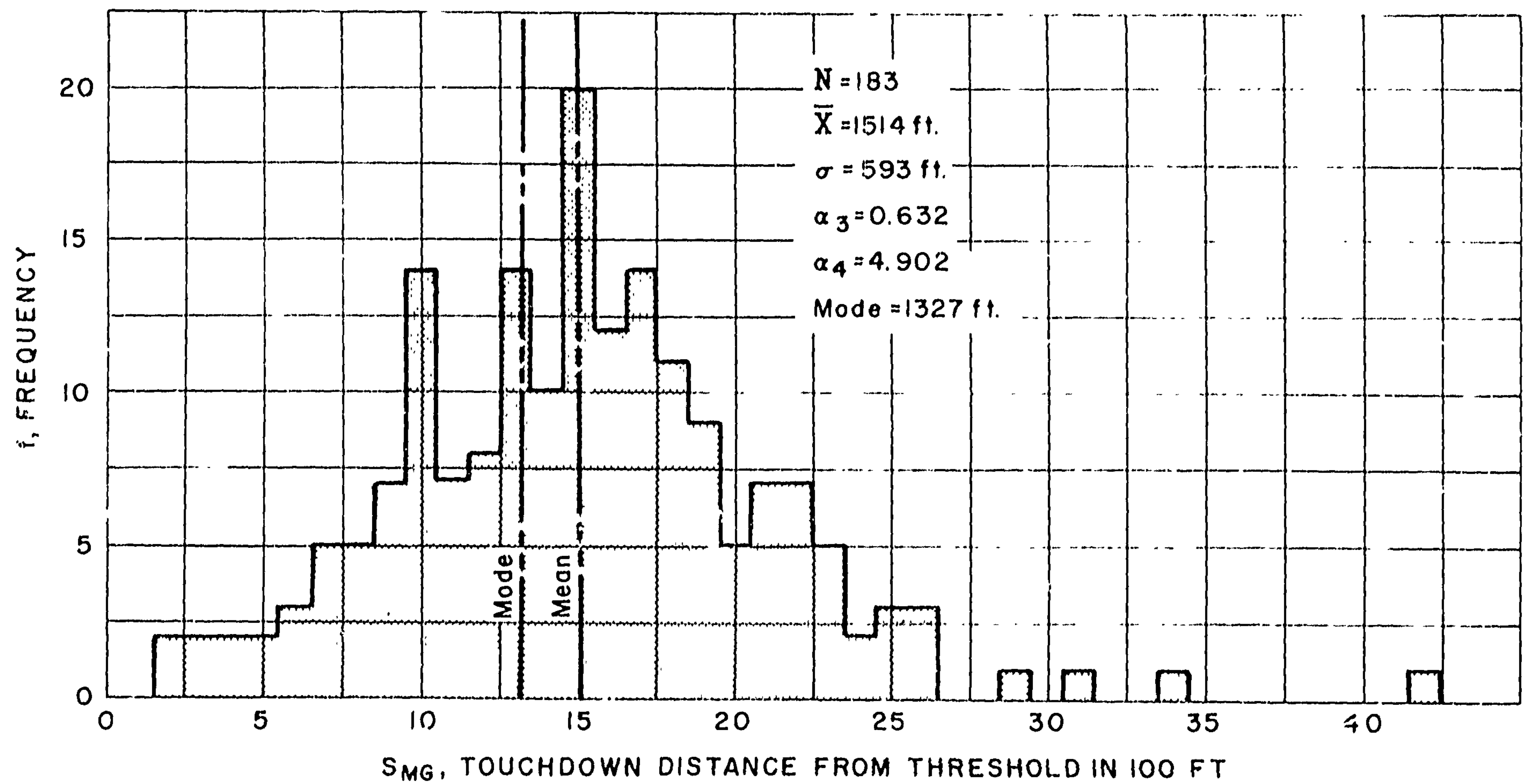


FIGURE 14, PROBABILITY OF EXCEEDING OR NOT EXCEEDING MAIN GEAR TOUCHDOWN DISTANCE FROM THRESHOLD

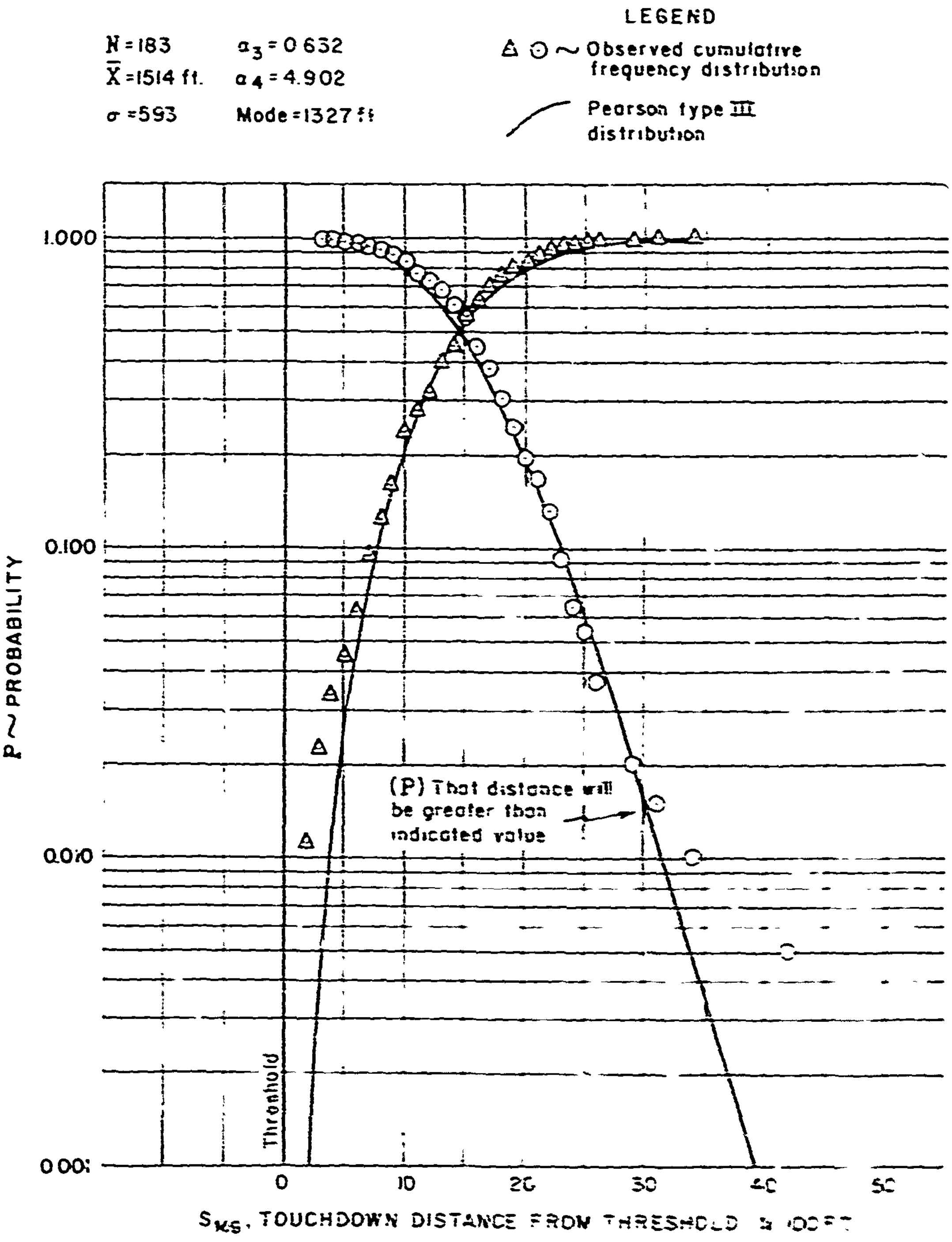


FIGURE 15, FREQUENCY DISTRIBUTION OF TOUCHDOWN SPEED RATIO

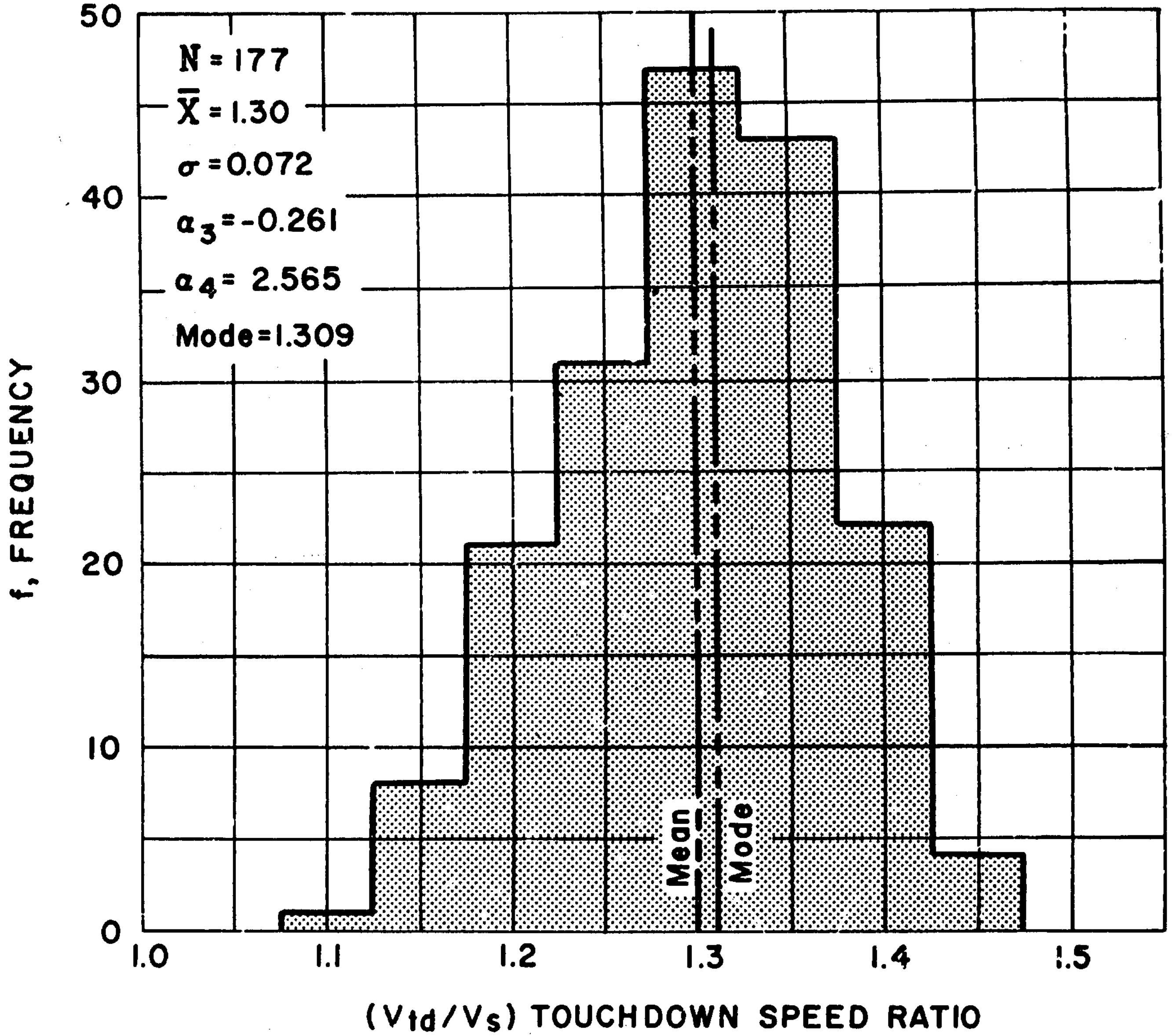


FIGURE 16, PROBABILITY OF EXCEEDING OR NOT EXCEEDING TOUCHDOWN SPEED RATIO

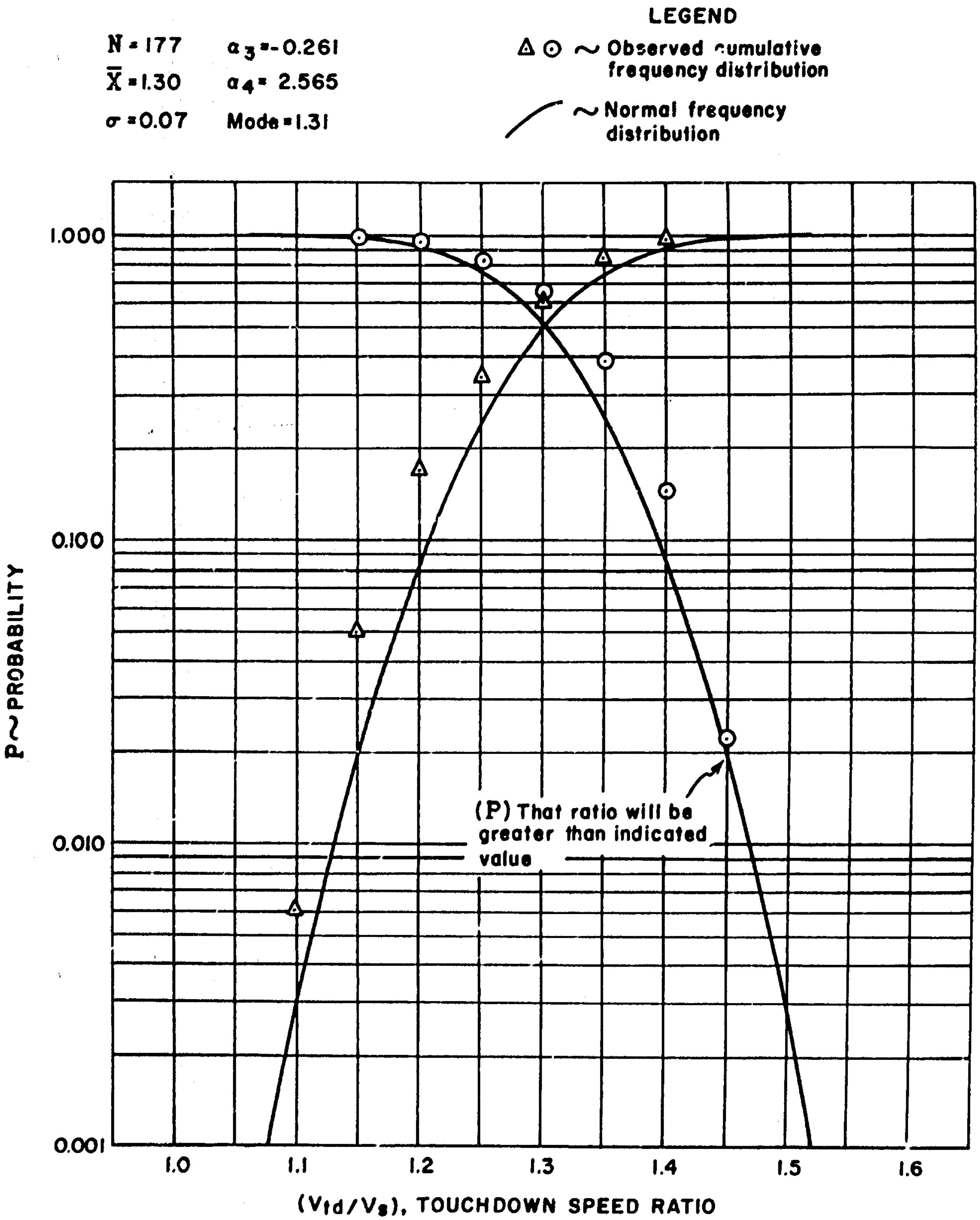


FIGURE 17, FREQUENCY DISTRIBUTION OF BLEEDOFF SPEED

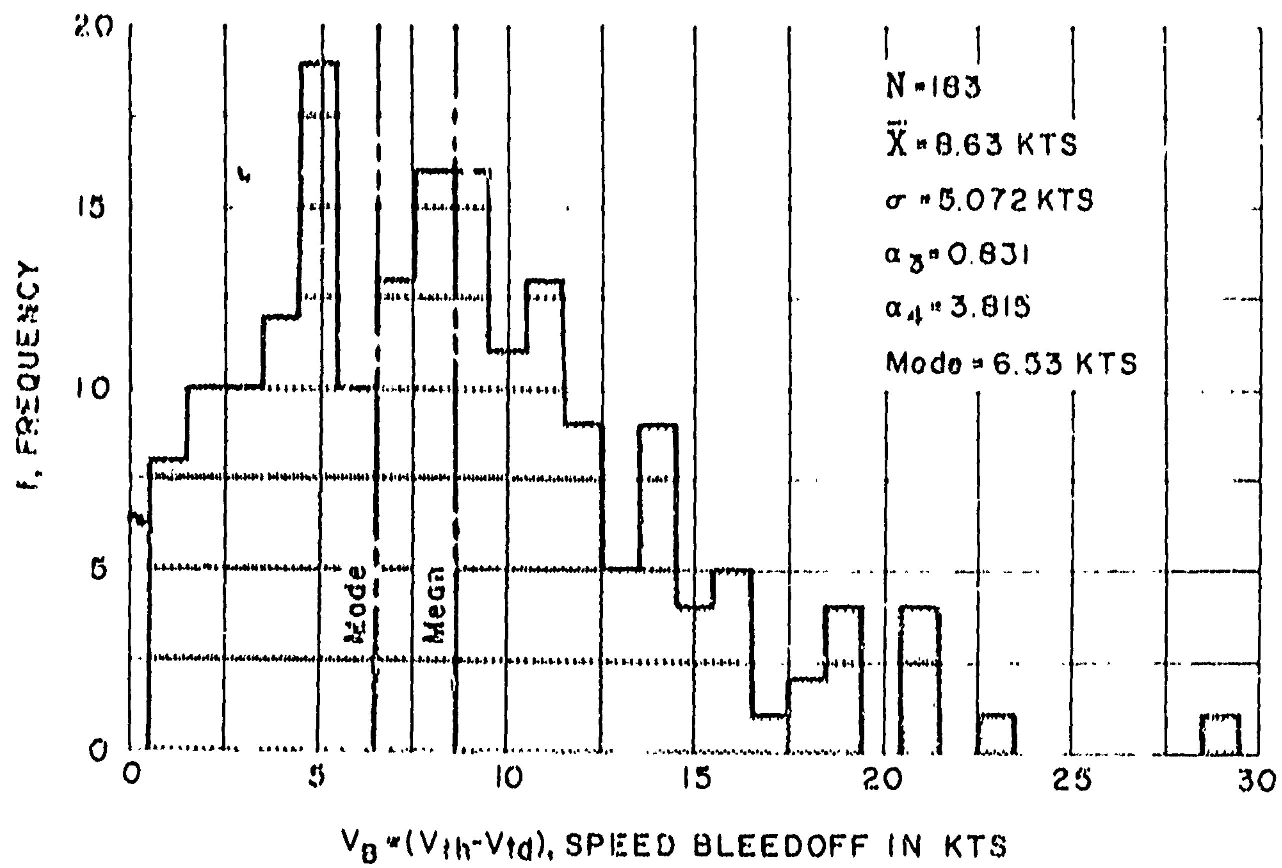


FIGURE 18, PROBABILITY OF EXCEEDING OR NOT EXCEEDING BLEEDOFF SPEED

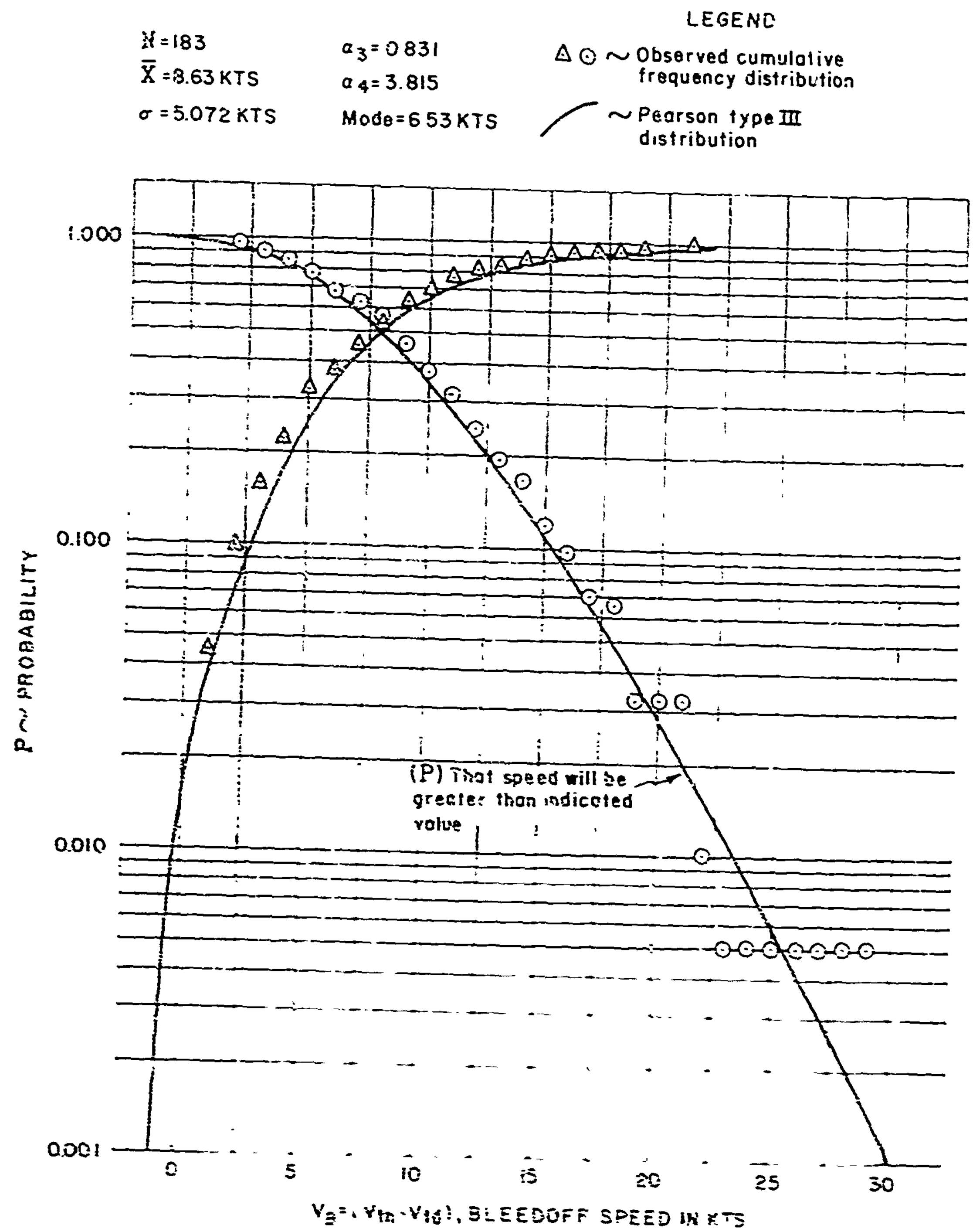


FIGURE 19, FREQUENCY DISTRIBUTION OF BLEEDOFF SPEED RATIO

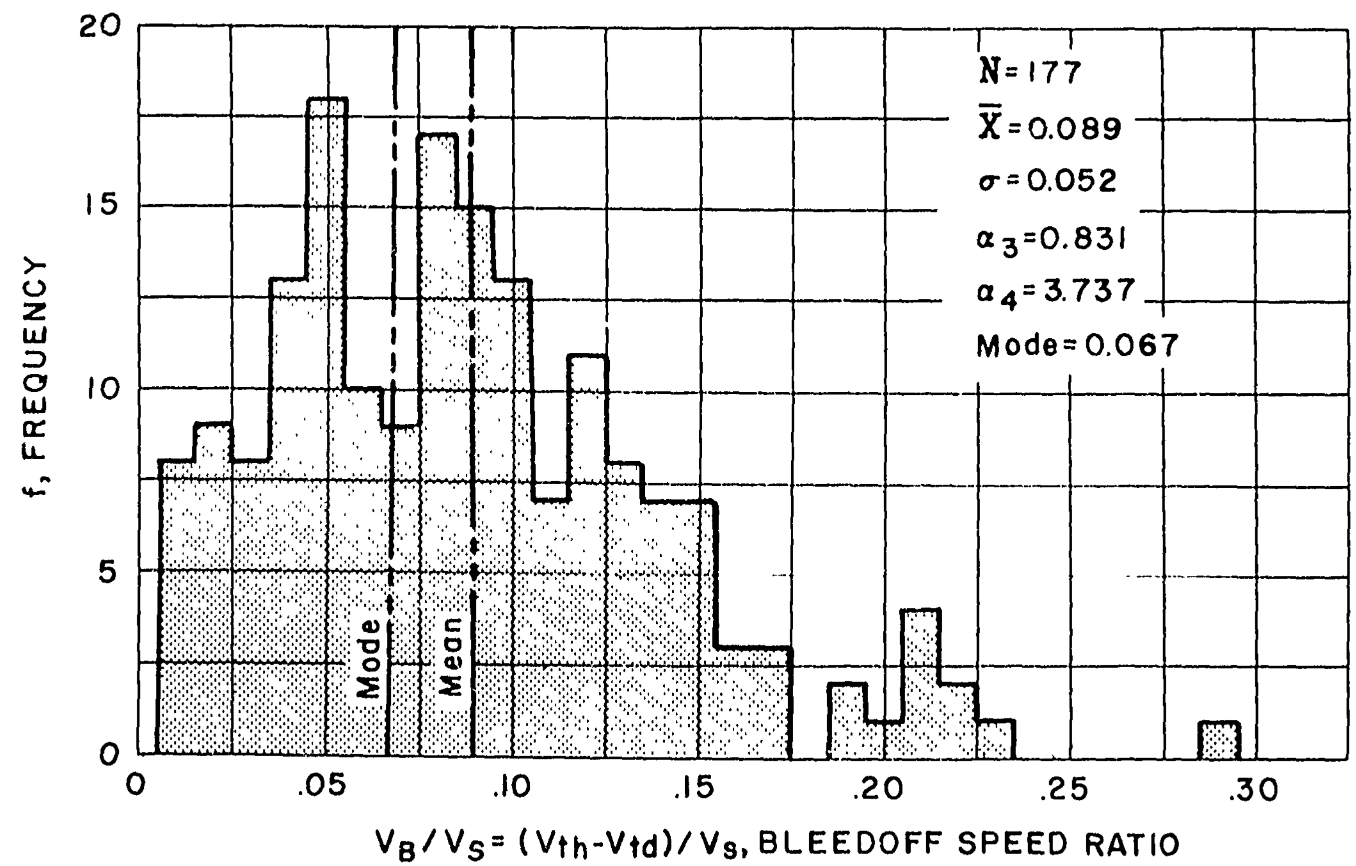


FIGURE 20, PROBABILITY OF EXCEEDING OR NOT EXCEEDING BLEEDOFF SPEED RATIO

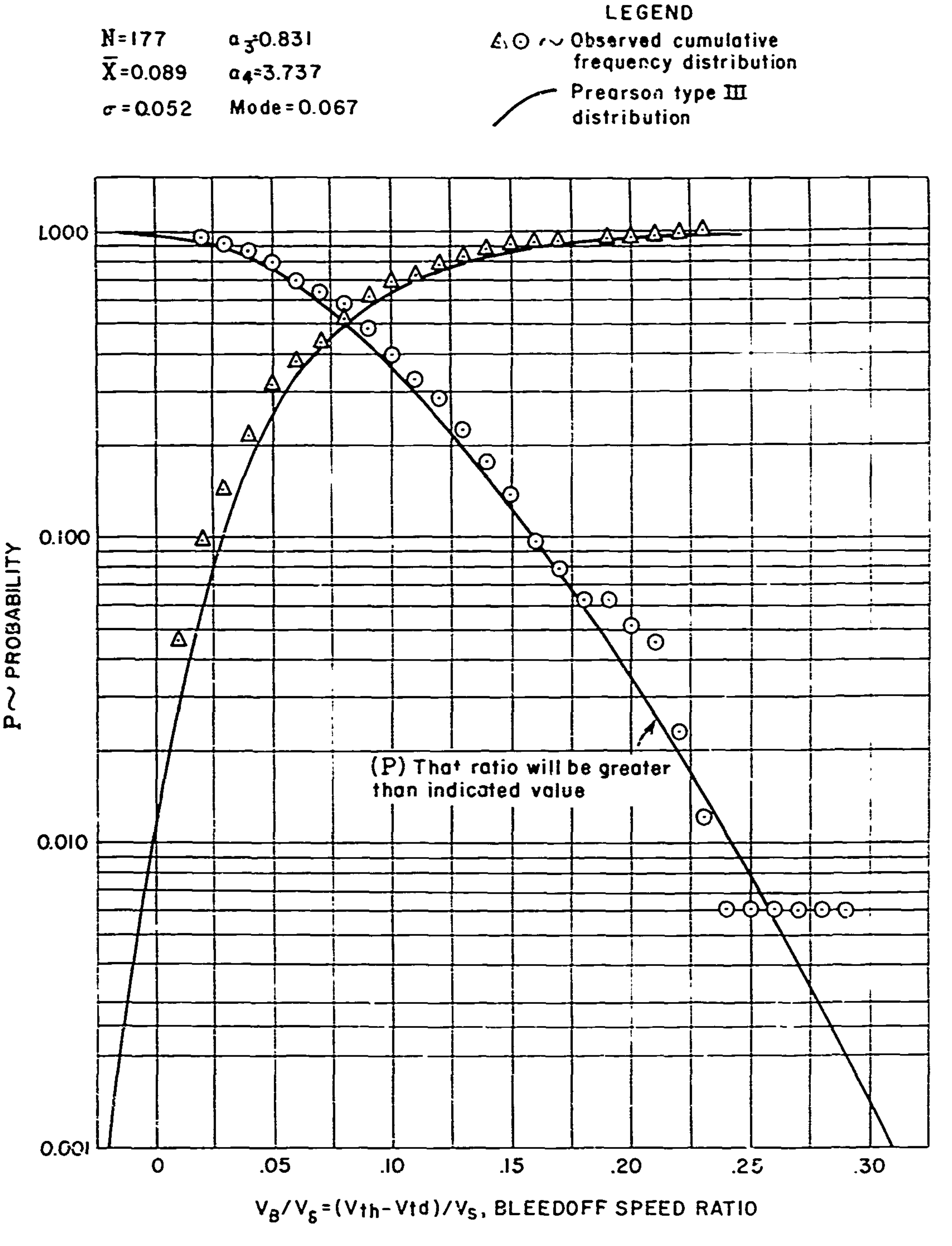


FIGURE 21, FREQUENCY DISTRIBUTION OF NOSEWHEEL DOWN TIME FROM TOUCHDOWN

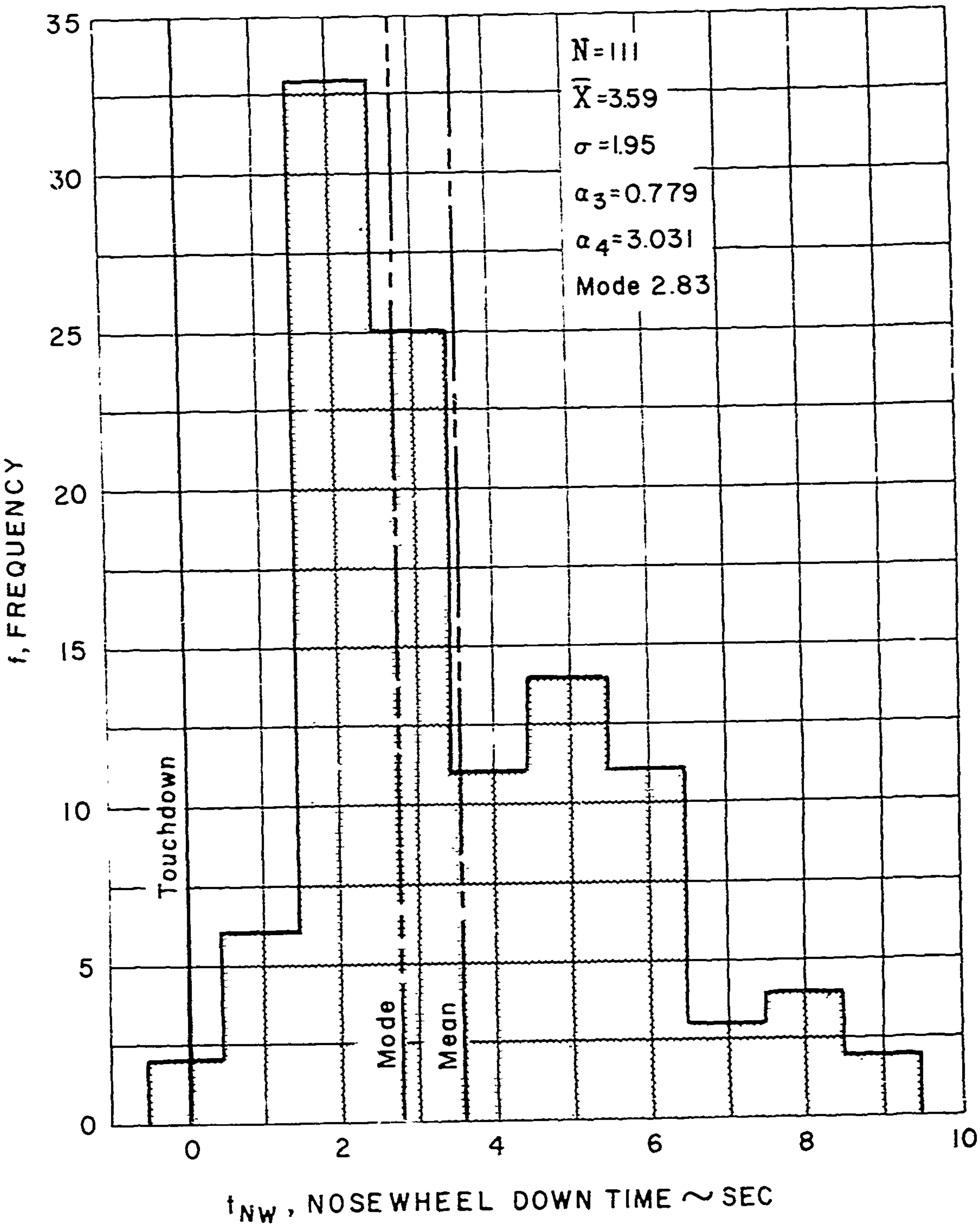


FIGURE 22, PROBABILITY OF EXCEEDING OR NOT EXCEEDING NOSE WHEEL TOUCHDOWN TIME FROM MAIN WHEEL TOUCHDOWN

$N = 111$ $\quad \alpha_3 = 0.779$

$\bar{X} = 3.59$ $\quad \alpha_4 = 3.031$

$\sigma = 1.95$ $\quad$ Mode = 2.83

LEGEND

△ ⊙ ~ Observed cumulative frequency distribution

/ ~ Pearson type III distribution

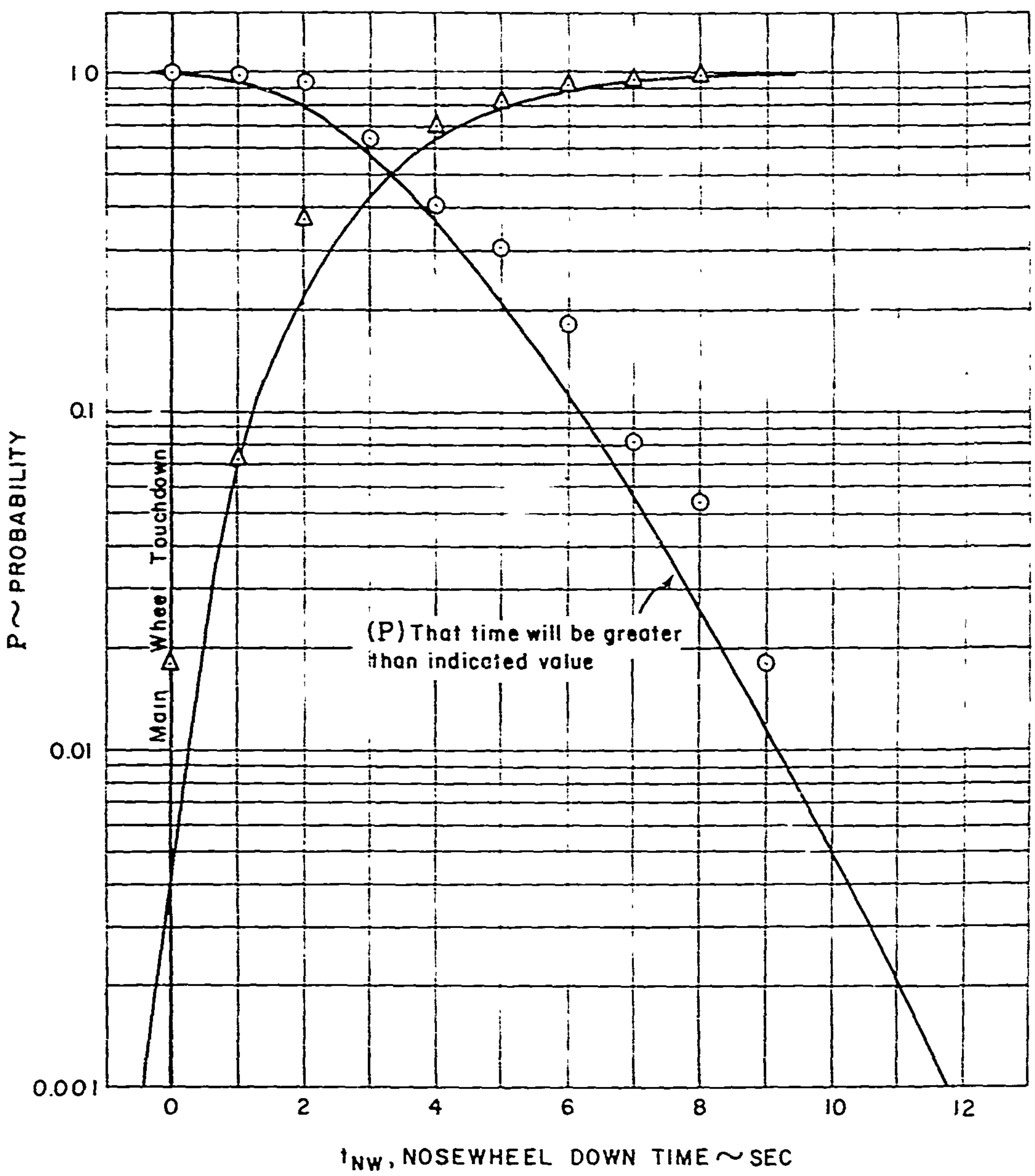


FIGURE 23, FREQUENCY DISTRIBUTION OF SPOILERS UP TIME FROM MAINGEAR TOUCHDOWN

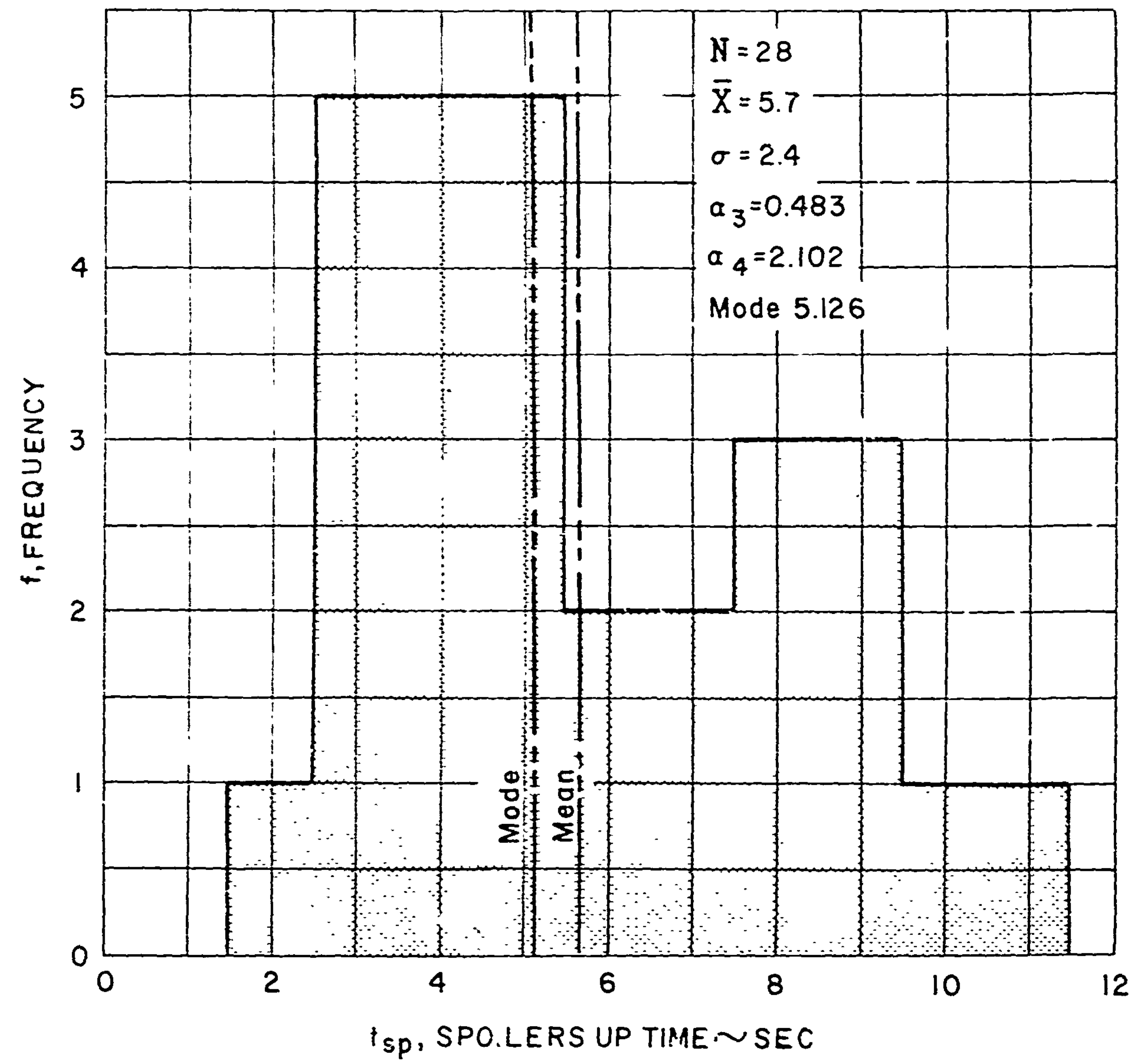


FIGURE 24, PROBABILITY OF EXCEEDING OR NOT EXCEEDING SPOILERS UP TIME FROM MAINGEAR TOUCHDOWN

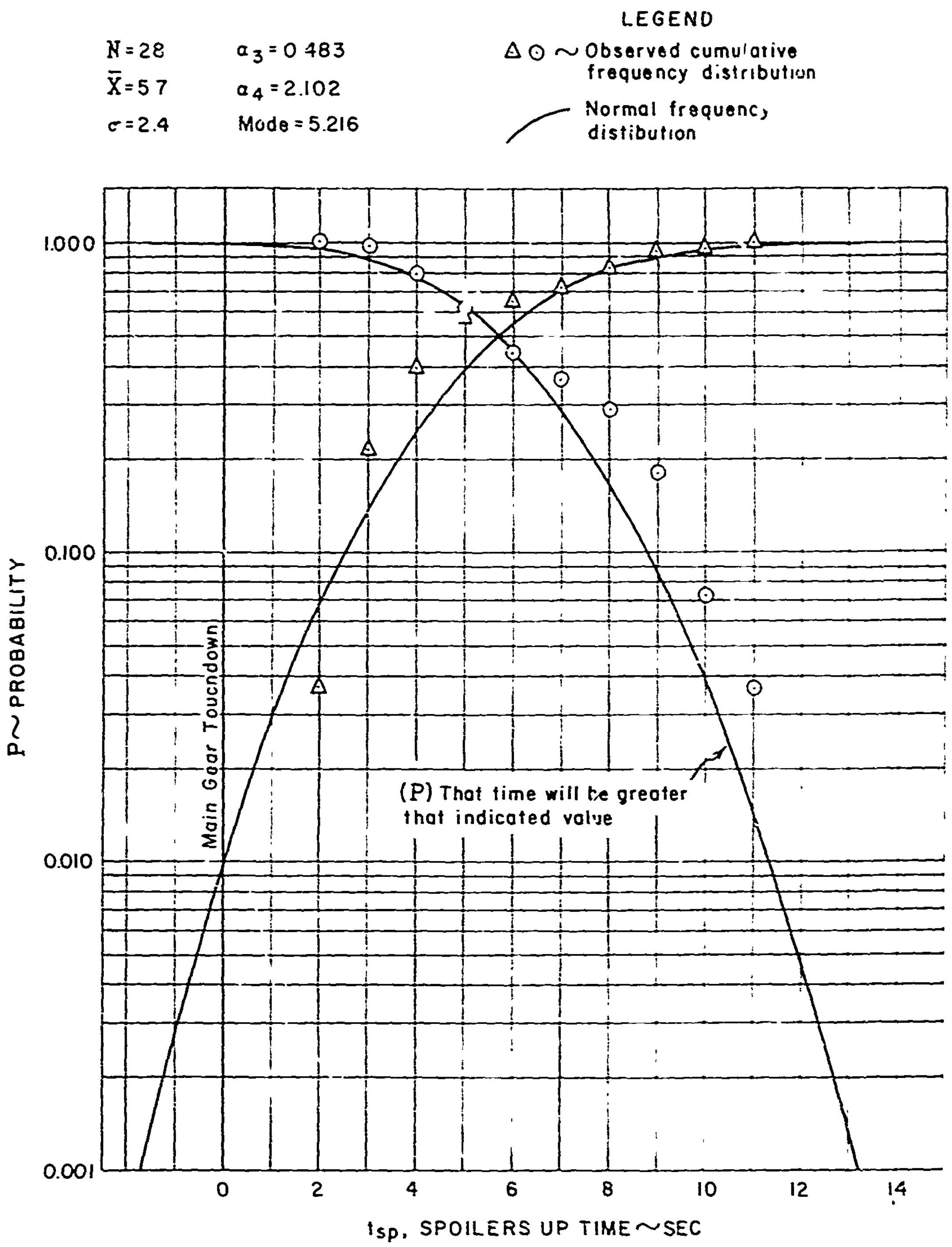


FIGURE 25, PROBABILITY THAT COMBINED VALUES OF FLARE-POINT HEIGHT AND FLARE-POINT DISTANCE TO THRESHOLD WILL LIE OUTSIDE OF GIVEN ENVELOPE

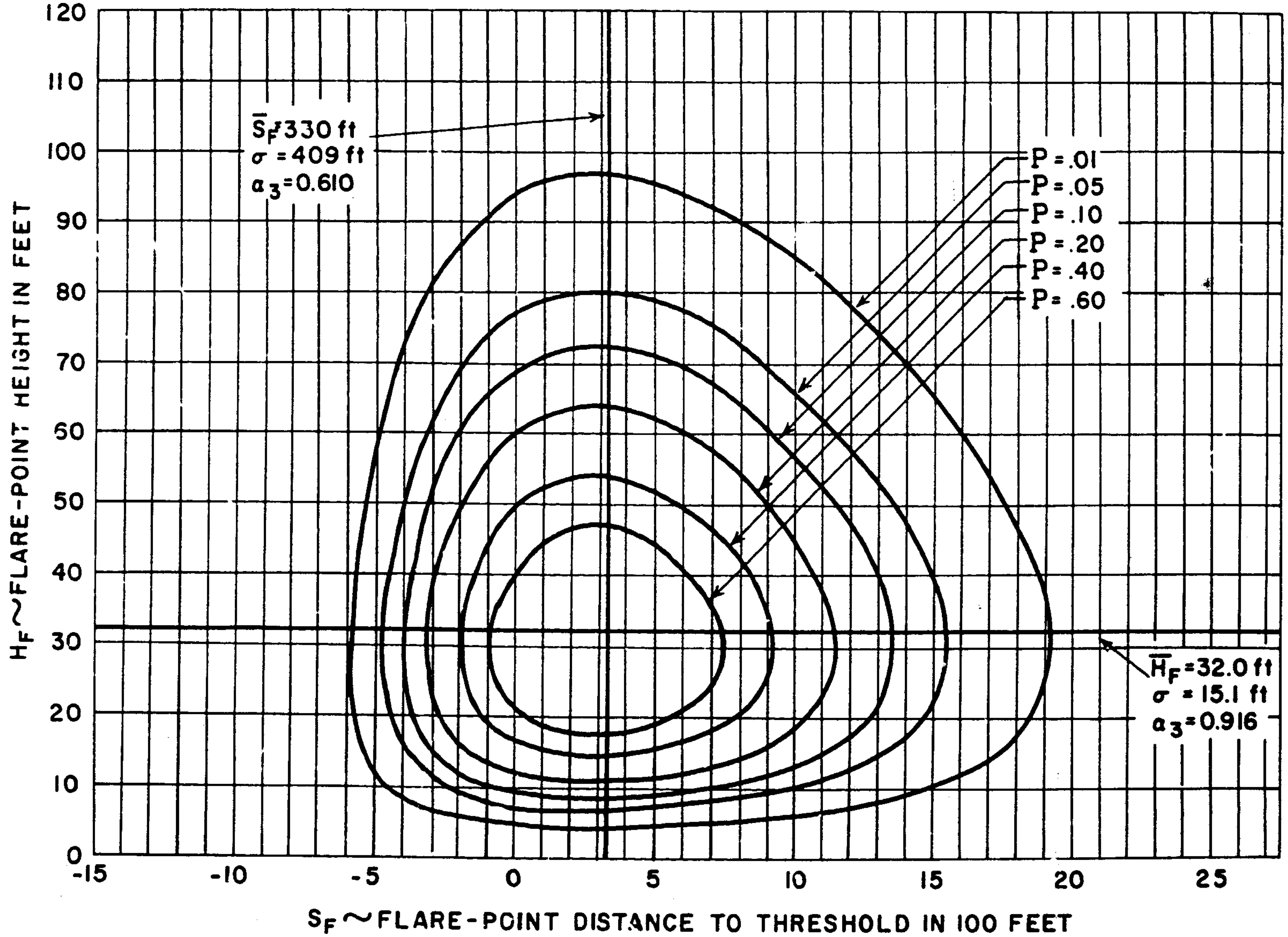
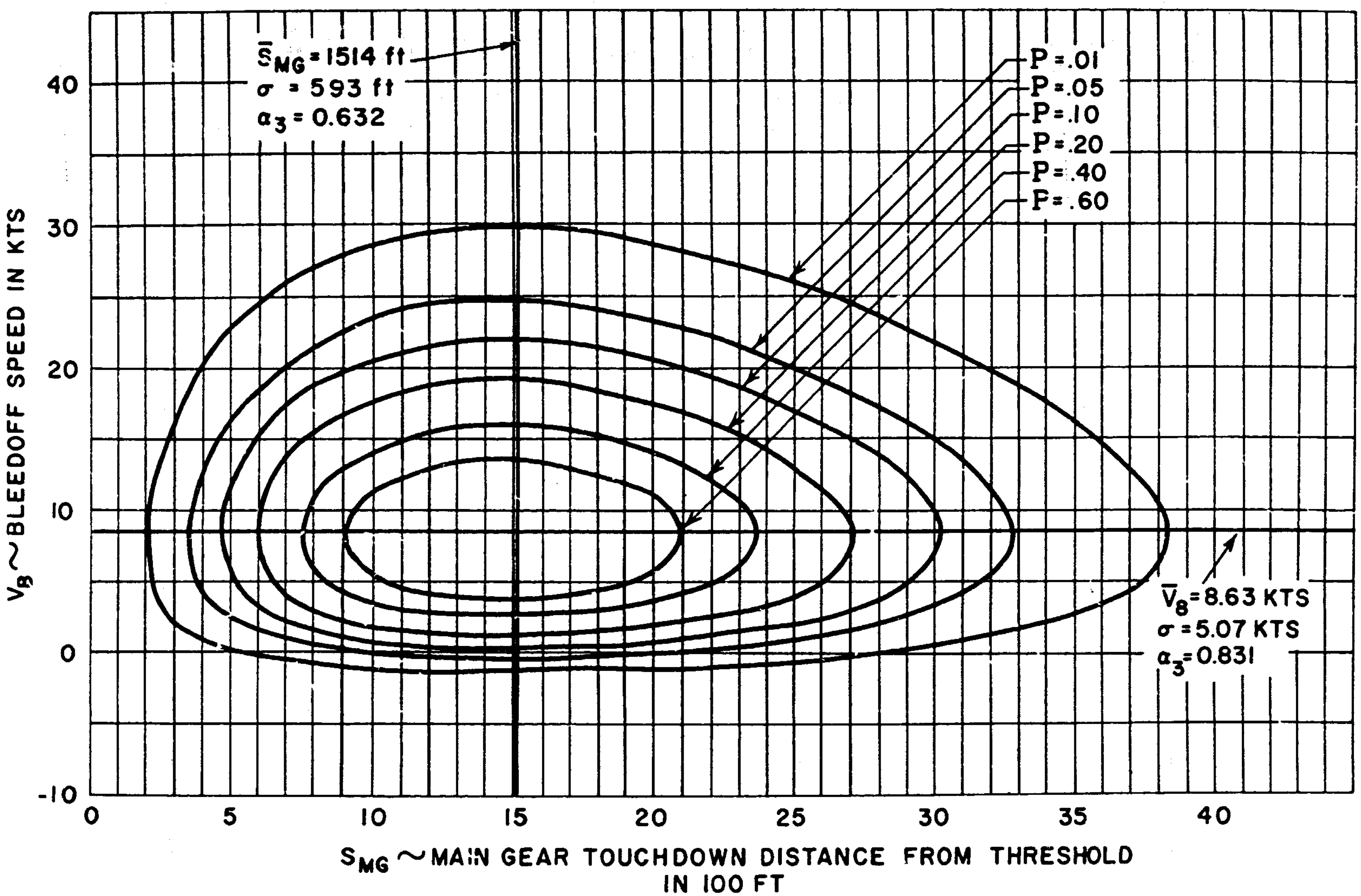


FIGURE 26, PROBABILITY THAT COMBINED VALUES OF BLEEDOFF SPEED AND MAIN GEAR TOUCHDOWN DISTANCE FROM THRESHOLD WILL LIE OUTSIDE OF GIVEN ENVELOPE



APPENDIX C

OBSERVED DATA
TABLES I THROUGH IV

TABLE I - OBSERVED DATA AT CHICAGO

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle $\theta°$	Approach Angle Ratio $\theta°/3.0$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold, (th) Height Ft./50	Threshold Speed, V_{th} CAS (kts)	Threshold Speed V_{th}/V_s	Main Gear Touchdown, (Td) Distance, Ft From (th)	Main Gear Touchdown Distance, Ft From 50'M	Main Gear Touchdown Speed, V_{td} CAS (kts)	Main Gear Touchdown Speed V_{td}/V_s	Bleedoff Speed V_B (kts)	Bleedoff Ratio V_B/V_s	Nose Wheel Down From Touchdown Dist. (Ft.)	Nose Wheel Down From Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
14	B-720	163.9	95.8	2.5	.83	1290	950	36.0	8.5	.17	133.0	1.39	646	1936	130.7	1.36	2.3	.024	87	0.39	—	—
15	DC-8	170.0	98.5	2.4	.80	420	-200	24.0	32.5	.65	127.1	1.29	1801	2221	116.4	1.18	10.7	.108	--	--	—	—
16	B-707	167.3	104.1	2.6	.87	880	400	28.5	13.0	.26	136.9	1.32	1333	2213	131.7	1.26	5.2	.050	478	2.05	—	—
17	DC-8	169.6	92.7	2.9	.97	580	260	34.0	24.0	.48	114.9	1.24	1773	2353	105.8	1.14	9.1	.098	768	4.27	—	—
18	CV-880	—	—	2.1	.70	1340	500	19.5	8.5	.17	131.2	—	988	2328	124.4	—	6.8	—	925	4.29	—	—
19	CV-880	113.8	101.7	2.9	.97	900	540	32.0	12.5	.25	137.0	1.35	853	1753	134.7	1.32	2.3	.023	612	2.63	—	—
20	DC-8	182.6	96.1	3.5	1.17	800	310	20.5	8.0	.16	129.2	1.34	886	1686	125.8	1.31	3.4	.035	818	3.73	—	—
21	B-720B	157.5	97.7	2.7	.90	660	470	41.5	23.5	.47	146.6	1.50	3418	4078	125.8	1.29	20.3	.213	471	2.03	—	—
22	B-707	159.5	101.9	1.6	.53	1140	-200	13.0	18.5	.37	136.2	1.34	1693	2833	129.8	1.27	6.4	.063	623	2.71	—	—
36	B-707	138.0	95.0	1.9	.63	560	200	36.0	32.0	.64	127.7	1.34	1614	2174	123.1	1.30	4.6	.046	222	1.04	—	—
37	B-720	164.3	96.2	2.1	.70	960	300	25.5	16.5	.33	131.3	1.36	1704	2664	126.8	1.32	4.5	.047	—	—	—	—
38	B-720B	171.4	101.9	3.3	1.10	[illegible]	1440	42.5	15.5	.31	135.3	1.33	2019	3669	127.3	1.25	8.0	.078	775	3.60	—	—
39	B-720	153.5	93.0	4.3	1.43	810	1060	66.0	10.5	.21	128.9	1.39	915	1725	125.5	1.35	3.4	.036	749	3.58	—	—
40	CV-880	117.4	102.7	3.6	1.20	790	780	49.5	17.5	.35	139.6	1.36	1343	2133	133.3	1.30	6.3	.061	727	3.23	—	—
41	DC-8	—	—	2.7	.90	1150	1220	53.0	15.0	.30	120.3	—	1562	2712	113.4	—	6.9	—	1008	5.20	—	—
42	B-707	170.0	107.0	3.0	1.00	560	1140	74.5	30.5	.61	149.2	1.39	2574	3134	138.3	1.29	10.9	.102	—	—	—	—
43	CV-880	124.6	106.2	2.4	.80	510	240	39.0	30.5	.61	140.1	1.32	2249	2759	130.9	1.23	9.2	.087	583	2.58	—	—
44	B-720B	168.0	100.8	2.6	.87	790	880	53.5	23.5	.47	130.2	1.29	1885	2675	121.0	1.20	9.2	.091	413	1.93	—	—
45	B-720B	170.2	101.5	2.1	.70	550	100	33.5	30.0	.60	132.3	1.30	2518	3068	124.8	1.23	7.5	.074	1136	5.23	—	—
46	CV-880	121.3	104.6	1.7	.57	1440	500	22.0	10.0	.20	134.2	1.28	977	2417	128.5	1.23	5.7	.054	567	2.52	—	—
47	CV-880	131.0	109.0	1.7	.57	1230	180	19.0	15.0	.30	136.5	1.25	1652	2882	126.7	1.16	9.8	.090	1172	5.41	—	—
48	CV-880	—	—	2.3	.77	1160	800	35.5	13.5	.27	129.6	—	1472	2632	122.7	—	6.9	—	463	2.15	—	—
49	DC-8	178.0	99.0	2.6	.87	1000	470	26.0	12.5	.25	127.3	1.29	1619	2619	117.5	1.19	9.8	.099	578	2.82	—	—
50	DC-8	170.0	96.0	4.2	1.40	700	1010	68.5	18.5	.37	119.6	1.25	1487	2187	112.1	1.17	715	.078	1405	7.34	—	—
51	CV-880	118.8	103.5	2.2	.73	790	120	24.5	20.5	.41	138.1	1.33	1288	2078	129.4	1.25	8.7	.084	1305	6.41	—	—
52	DC-8	—	—	2.5	.83	1020	590	32.0	[illegible]	.27	127.7	—	1715	2735	122.0	—	5.7	—	956	4.70	—	—
53	CV-880	124.9	106.3	3.5	1.17	1360	1300	47.0	[illegible]	.22	142.7	1.34	2197	3557	128.3	1.21	14.4	.135	1591	7.66	—	—
54	DC-8	185.9	97.0	2.8	.93	670	200	27.0	[illegible]	.38	132.4	1.36	2294	2964	121.7	1.25	10.7	.110	1614	7.99	—	—
55	B-720	148.5	91.2	2.8	.93	700	400	35.0	19.0	.38	126.4	1.39	2199	2899	120.1	1.32	6.3	.069	961	4.75	—	—
56	B-720	146.8	90.8	2.9	.96	700	350	32.5	18.5	.37	126.9	1.40	796	1496	122.3	1.35	4.6	.051	452	2.16	—	—
57	DC-8	174.6	97.9	3.3	1.10	1110	920	39.0	7.0	.14	123.1	1.26	738	1848	117.7	1.20	5.4	.055	673	3.38	—	—
58	B-720	141.0	88.5	2.2	.73	1300	740	27.0	6.5	.13	125.7	1.42	302	1602	125.2	1.41	0.5	.006	—	—	—	—
59	B-707	145.0	97.0	2.8	.93	1020	780	38.0	12.0	.24	136.0	1.40	1018	2038	131.4	1.35	4.6	.047	1282	6.21	—	—

TABLE I - OBSERVED DATA AT CHICAGO - CONT'D

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle θ°	Approach Angle Ratio $\frac{\theta^\circ}{3.0}$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold, (th) Height $\frac{Ft.}{50}$	Threshold, (th) Speed, V_{th} CAS (kts)	Threshold, (th) Speed, V_{th} $\frac{V_{th}}{V_s}$	Main Gear Touchdown, (td) Distance, ft. From (th)	Main Gear Touchdown, (td) Distance, ft. From 50'H	Main Gear Touchdown, (td) Speed, V_{td} CAS (kts)	Main Gear Touchdown, (td) Speed, V_{td} $\frac{V_{td}}{V_s}$	Bleedoff Speed V_B (kts)	Bleedoff Ratio $\frac{V_B}{V_s}$	Nose Wheel Down from Touchdown Dist. (Ft.)	Nose Wheel Down from Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
61	B-707	170.0	107.0	2.7	.90	460	600	55.5	33.0	.66	148.1	1.38	1758	2218	143.6	1.34	4.5	.042	846	3.67	----	----
62	DC-8	176.5	98.5	2.6	.87	960	480	27.5	11.0	.22	126.1	1.28	1452	2412	117.5	1.19	8.6	.087	608	3.06	----	----
63	B-720	146.9	90.8	3.1	1.03	1140	930	38.5	3.5	.07	130.8	1.44	220	1360	129.0	1.42	1.8	.020	570	2.60	----	----
64	DC-8	185.0	100.8	2.8	.93	810	680	43.5	16.5	.33	121.7	1.21	1490	2300	112.7	1.12	9.0	.089	716	4.32	----	----
65	DC-8	170.2	96.5	2.3	.77	1140	640	30.0	10.0	.20	129.5	1.34	1590	2730	121.5	1.26	8.0	.083	1330	6.31	----	----
66	CV-880	119.5	103.6	3.2	1.07	680	380	33.0	17.0	.34	152.4	1.47	1702	2382	140.4	1.36	12.0	.116	498	2.11	----	----
67	B-720	143.2	89.2	1.8	.60	1310	790	34.0	15.0	.30	134.2	1.50	1618	2928	130.7	1.46	3.5	.039	----	----	----	----
68	DC-8	180.8	99.8	2.5	.83	1120	880	40.0	10.5	.21	127.3	1.28	1502	2622	120.5	1.21	6.8	.068	----	----	----	----
69	CV-580	128.7	108.0	2.7	.90	1270	800	27.5	3.5	.07	139.0	1.29	1354	2624	131.0	1.21	8.0	.074	1846	9.07	----	----
70	DC-8	174.0	97.7	3.9	1.30	1110	1280	59.5	9.0	.18	127.3	1.30	1884	2994	110.8	1.13	16.5	.169	1124	6.30	----	----
71	CV-880	122.0	104.6	2.5	.83	890	140	14.5	10.0	.20	140.9	1.35	1266	2156	134.6	1.29	6.3	.060	672	3.07	----	----
72	CV-880	114.0	101.4	2.3	.77	890	250	24.5	16.5	.33	134.6	1.33	1424	2314	126.1	1.24	8.5	.084	500	2.40	----	----
73	B-707	177.6	100.0	2.3	.77	1680	950	22.0	5.5	.11	132.1	1.32	1517	3197	124.7	1.25	7.4	.074	315	1.54	----	----
74	B-707	152.8	99.8	5.0	1.67	250	760	85.0	35.0	.70	144.3	1.45	2217	2477	125.6	1.26	18.7	.187	603	2.88	----	----
75	DC-8	173.0	97.5	2.7	.90	1400	1400	50.0	8.0	.16	126.5	1.30	1664	3064	115.2	1.18	11.3	.116	----	----	----	----
76	B-707	145.0	97.0	1.4	.47	1570	800	33.0	7.0	.14	129.4	1.33	694	2264	127.1	1.31	2.3	.024	48	0.21	----	----
77	DC-8	177.1	98.5	2.1	.70	1770	1120	28.5	5.0	.10	126.7	1.29	520	2290	125.0	1.27	1.7	.017	1364	6.70	----	----
78	B-707	166.0	103.8	2.5	.83	1370	860	28.5	7.5	.15	138.6	1.34	1219	2589	134.5	1.30	4.1	.039	1053	4.90	----	----
79	DC-8	176.3	98.5	2.7	.90	730	370	33.5	19.5	.39	127.2	1.29	1455	2185	118.1	1.20	9.1	.092	925	4.78	----	----
80	CV-880	118.9	103.3	3.1	1.03	1060	610	26.0	6.0	.12	130.0	1.26	1045	2105	122.6	1.19	7.4	.072	778	3.91	----	----

TABLE II - OBSERVED DATA AT SAN FRANCISCO

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle $\theta°$	Approach Angle Ratio $\frac{\theta°}{3.0}$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold Height $\frac{Ft.}{50}$	Threshold Speed, V_{th} CAS (kts)	Threshold Speed $\frac{V_{th}}{V_s}$	Main Gear Touchdown, (td) Distance, Ft. From (th)	Main Gear Touchdown Distance, Ft. From 50'R	Main Gear Touchdown Speed, V_{td} CAS (kts)	Main Gear Touchdown Speed $\frac{V_{td}}{V_s}$	Bleedoff Speed V_B (kts)	Bleedoff Ratio $\frac{V_B}{V_s}$	Nose Wheel Down from Touchdown Dist. (Ft.)	Nose Wheel Down from Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
85	B-720	148.5	91.0	3.2	1.07	820	820	50.0	12.0	.24	133.3	1.46	967	1787	127.3	1.40	6.0	.066	—	—	—	—
86	B-720	145.8	90.0	3.5	1.17	570	930	68.0	27.5	.55	138.9	1.54	1724	2294	126.0	1.40	12.9	.143	—	—	—	—
87	B-707	151.2	99.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.19	—	—
88	B-720	145.0	90.0	2.2	.73	820	-50	17.0	19.0	.38	139.6	1.55	1251	2071	127.9	1.42	11.7	.130	—	—	—	—
89	B-707	165.0	104.0	3.2	1.07	890	600	34.0	11.5	.23	143.2	1.38	974	1864	131.2	1.26	12.0	.115	137[illegible]	7.51	—	—
90	B-707	153.6	100.0	1.3	.43	780	830	63.0	24.0	.48	135.9	1.36	1733	2513	119.7	1.20	16.2	.162	—	—	—	—
91	DC-8	151.1	91.0	0.8	.27	1260	700	42.5	3.5	.07	122.1	1.34	193	1453	121.2	1.33	0.9	.010	381	2.31	—	—
92	DC-8	169.0	92.2	3.4	1.13	470	100	28.0	23.0	.46	133.1	1.44	1278	1748	122.0	1.32	11.1	.120	914	5.66	—	—
93	B-720B	154.0	96.0	3.3	1.10	660	260	27.0	14.0	.28	142.5	1.46	1534	2194	131.0	1.36	11.5	.120	—	—	—	—
94	B-720	149.7	92.0	3.1	1.03	500	180	32.0	24.5	.49	131.7	1.43	1260	1760	124.4	1.35	7.3	.079	—	—	—	—
95	B-720B	152.4	96.0	3.5	1.17	270	-80	18.5	23.5	.47	135.5	1.41	751	1021	132.9	1.38	2.6	.027	403	2.26	—	—
96	B-707	155.8	101.0	3.7	1.23	630	460	38.5	14.0	.28	145.8	1.44	1649	2279	130.8	1.30	15.0	.148	233	1.35	—	—
97	B-720B	155.0	97.0	3.3	1.10	500	520	48.0	23.5	.47	141.6	1.46	1291	1791	132.1	1.36	9.5	.098	266	1.52	—	—
98	B-720	146.3	90.0	4.3	1.43	300	-70	23.0	28.0	.56	126.7	1.41	1026	1326	121.4	1.35	5.3	.059	349	2.19	—	—
103	B-720	153.0	93.0	3.0	1.00	745	830	54.5	16.0	.32	125.2	1.35	774	1519	121.7	1.31	3.5	.038	384	2.06	—	—
104	B-720	152.0	92.0	2.8	.93	975	210	12.5	6.5	.13	123.1	1.34	470	1445	121.9	1.32	1.2	.013	1075	5.96	—	—
105	B-707	141.6	96.0	2.7	.90	1290	1600	63.0	14.5	.29	144.8	1.51	1207	2497	141.5	1.47	3.3	.034	187	0.85	—	—
106	B-720	167.0	97.0	2.4	.80	870	500	36.8	19.5	.39	128.8	1.33	1571	2441	124.1	1.28	4.7	.048	—	—	—	—
107	B-720B	160.0	98.0	3.2	1.07	800	360	26.5	12.5	.25	148.2	1.51	1768	2568	138.2	1.41	10.0	.102	935	4.54	—	—
108	B-707	155.0	100.4	2.6	.87	450	150	37.0	31.5	.63	150.8	1.50	1805	2255	141.2	1.41	9.6	.096	271	1.39	—	—
109	B-720	170.7	98.0	3.4	1.13	210	-90	33.5	38.5	.77	133.5	1.36	2536	2746	[illegible]	1.22	13.5	.138	841	4.88	948	5.54
110	B-707	150.8	99.0	1.9	.63	800	-200	17.0	23.0	.46	140.8	1.42	2546	3346	125.7	1.27	15.1	.152	579	3.07	837	4.48
116	B-720B	158.0	98.0	3.0	1.00	360	80	35.0	31.0	.62	144.8	1.48	2086	2446	128.4	1.31	16.4	.167	411	2.25	—	—
117	DC-8	169.0	96.0	4.6	1.53	570	400	37.0	15.0	.30	124.8	1.30	1035	1605	113.8	1.18	11.0	.115	718	4.60	—	—
118	B-720	148.0	91.0	5.0	1.67	170	225	53.5	39.5	.79	143.4	1.58	1607	1777	129.7	1.42	13.7	.151	457	2.47	—	—
119	[illegible]-720	175.0	99.0	4.1	1.37	475	100	23.0	17.0	.34	122.5	1.24	882	1357	112.9	1.14	9.6	.097	1183	7.58	1694	11.14
120	DC-8	137.0	96.0	3.7	1.23	480	1000	81.5	26.0	.52	134.1	1.40	1640	2120	122.0	1.27	12.1	.126	—	—	—	—
121	B-720	155.0	93.0	2.4	.80	195	-560	19.0	42.0	.84	135.3	1.45	2052	2247	126.9	1.36	8.4	.090	—	—	—	—
122	B-720	148.1	91.0	2.7	.90	320	70	38.0	35.0	.70	129.0	1.42	926	1246	124.6	1.37	4.4	.048	674	3.32	—	—
123	B-707	141.2	96.0	2.6	.87	410	-250	21.0	31.0	.62	130.3	1.36	1244	1654	125.6	1.31	4.7	.049	523	2.52	—	—
124	B-720B	150.0	95.0	2.5	.83	550	200	35.0	27.0	.54	133.0	1.40	1792	2342	121.4	1.28	11.6	.122	655	3.22	—	—
125	B-707	146.0	98.0	1.6	.53	400	-200	22.0	31.0	.62	135.0	1.38	1660	2060	126.9	1.29	8.1	.083	—	—	—	—

TABLE II - OBSERVED DATA AT SAN FRANCISCO - CONT'D

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle θ^o	Approach Angle Ratio $\frac{\theta^o}{3.0}$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold Height $\frac{Ft.}{50}$	Threshold Speed, V_{th} CAS (kts)	Threshold $\frac{V_{th}}{V_s}$	Main Gear Touchdown, (td) Distance, Ft. From (th)	Main Gear Touchdown Distance, Ft. From 50'H	Main Gear Touchdown Speed, V_{td} CAS (kts)	Main Gear Touchdown $\frac{V_{td}}{V_s}$	Bleedoff Speed V_B (kts)	Bleedoff Ratio $\frac{V_B}{V_s}$	Nose Wheel Down from Touchdown Dist. (Ft.)	Nose Wheel Down from Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
128	B-707	162.0	103.0	2.3	1.10	495	200	33.0	23.5	.47	146.8	1.42	1722	2217	134.0	1.30	12.8	.124	703	3.49	1520	7.32
129	B-720	142.2	89.0	4.5	1.50	425	270	38.0	22.0	.44	127.8	1.44	1445	1870	116.1	1.30	11.7	.131	977	6.11	1223	7.75
130	B-720	141.0	89.0	3.9	1.30	290	180	42.0	32.5	.65	133.2	1.50	1706	1996	119.7	1.34	13.5	.152	826	5.09	1414	9.01
131	B-707	155.0	101.0	3.0	1.00	510	440	47.0	31.0	.62	158.1	1.56	2428	2938	135.6	1.34	22.5	.223	261	1.38	681	3.64
132	B-720	153.0	93.0	2.8	.93	860	100	13.0	9.0	.18	130.5	1.40	976	1836	121.1	1.30	9.4	.101	982	6.10	1529	9.81
133	DC-8	167.0	96.0	3.1	1.03	760	250	20.0	10.0	.20	124.8	1.30	1279	2039	112.5	1.17	12.3	.128	854	5.53	1305	8.82
136	B-707	163.5	103.0	3.4	1.13	680	200	22.0	15.0	.30	139.7	1.36	1746	2426	136.7	1.33	3.0	.029	315	1.58	1187	6.11
137	B-720	142.5	89.0	3.1	1.03	420	320	44.0	27.5	.55	117.1	1.32	1134	1554	114.1	1.28	3.0	.034	704	4.50	—	—
138	B-720	143.0	89.0	3.9	1.30	300	-130	22.0	30.0	.60	113.8	1.28	868	1168	111.4	1.25	2.4	.027	373	2.50	631	4.53
139	B-720B	165.0	100.0	2.3	.77	300	-300	26.0	38.0	.76	144.2	1.44	2607	2907	136.5	1.36	7.7	.077	214	1.15	723	3.88
140	DC-8	166.7	96.0	4.1	1.37	400	200	36.0	24.0	.48	118.2	1.23	1520	1920	112.3	1.17	5.9	.061	565	3.80	1043	7.14
142	DC-8	170.1	87.0	4.1	1.37	540	120	20.0	15.0	.30	111.1	1.28	589	1129	110.5	1.27	0.6	.007	750	5.16	—	—
143	DC-8	178.0	99.0	2.3	.77	700	200	30.0	24.0	.48	127.1	1.28	1892	2592	112.7	1.14	14.4	.145	1062	5.76	1416	8.97
144	B-720	143.2	89.0	2.5	.83	300	200	45.5	38.0	.76	130.3	1.46	1872	2172	118.9	1.34	11.4	.128	387	2.21	936	4.89
148	B-707	141.5	96.0	2.9	.96	400	-300	14.0	29.0	.58	137.0	1.42	933	1333	134.7	1.40	2.3	.024	449	2.23	—	—
149	DC-8	179.0	99.0	3.0	1.00	320	100	38.0	34.0	.68	129.0	1.30	1514	1834	120.8	1.22	8.2	.083	—	—	—	—
150	B-720	142.5	89.0	3.0	1.00	250	100	42.0	38.0	.76	133.2	1.50	1966	2216	122.6	1.38	10.6	.119	—	—	—	—
151	DC-8	170.0	97.0	2.7	.90	360	200	43.0	34.5	.69	125.4	1.29	1697	2057	116.4	1.20	9.0	.093	—	—	—	—
152	B-720B	160.0	98.0	2.5	.83	880	200	21.5	14.5	.29	132.6	1.35	1073	1953	122.7	1.25	9.9	.101	586	2.92		
153	B-720B	170.6	100.0	2.0	.67	980	-200	10.0	16.0	.32	135.2	1.35	1055	2035	132.8	1.33	2.4	.024	—	—	1566	7.25
154	DC-8	155.0	92.0	2.9	.96	450	-100	23.0	27.5	.55	126.8	1.38	1438	1888	118.6	1.29	8.2	.089	—	—	—	—
155	B-707	147.8	98.0	3.3	1.10	930	500	27.0	6.0	.12	129.9	1.33	333	1263	127.7	1.30	2.2	.022	1179	5.76	466	2.20
156	DC-8	167.0	96.0	4.0	1.33	540	200	26.0	16.0	.32	128.2	1.34	1521	2061	117.9	1.23	10.3	.107	—	—	—	—
157	B-707	—	—	2.5	.83	580	60	28.0	26.0	.52	148.3	—	1766	2346	134.3	—	14.0	—	697	3.31	—	—
158	B-707	—	—	2.9	.96	460	50	29.0	27.0	.54	148.5	—	2201	2661	132.7	—	15.8	—	405	2.01	621	3.10
159	DC-8	170.0	97.0	2.9	.96	660	40	18.5	17.0	.34	145.4	1.50	1874	2534	137.8	1.42	7.6	.078	707	3.45	1623	8.20

TABLE III - OBSERVED DATA AT DENVER

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle $\theta°$	Approach Angle Ratio $\frac{\theta°}{3.0}$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold, (th) Height $\frac{Ft.}{50}$	Threshold, (th) Speed, V_{th} CAS (kts)	Threshold, (th) Speed, V_{th} $\frac{V_{th}}{V_s}$	Main Gear Touchdown, (td) Distance, ft. From (th)	Main Gear Touchdown, (td) Distance, ft. From 50'H	Main Gear Touchdown, (td) Speed, V_{td} CAS (kts)	Main Gear Touchdown, (td) Speed, V_{td} $\frac{V_{td}}{V_s}$	Bleedoff Speed V_B (kts)	Bleedoff Ratio $\frac{V_B}{V_s}$	Nose Wheel Down from Touchdown Dist. (Ft.)	Nose Wheel Down from Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
166	DC-8	177.0	98.5	2.5	.83	860	500	34.5	18.5	.37	122.8	1.25	1631	2491	119.1	1.21	3.7	.038	1850	9.47	—	—
167	B-720	153.3	92.5	2.1	.70	570	-400	16.0	29.0	.58	128.5	1.39	1557	2127	121.1	1.31	7.4	.080	—	—	—	—
168	B-707	155.6	101.0	2.7	.90	680	100	23.0	20.0	.40	140.0	1.39	1452	2132	137.5	1.36	2.5	.025	—	—	777	3.21
169	B-707	153.6	100.0	1.9	.63	1000	-140	12.0	16.0	.32	144.1-	1.44	1006	2006	139.2	1.39	4.9	.049	—	—	—	—
170	DC-8	143.0	88.3	2.9	.97	860	280	21.0	12.5	.25	117.3	1.33	888	1748	112.6	1.28	4.7	.053	—	—	724	3.66
172	DC-8	149.0	90.0	4.4	1.47	760	580	36.0	11.5	.23	124.5	1.38	977	1731	119.7	1.33	4.8	.053	—	—	—	—
173	B-707	157.0	101.0	3.1	1.03	380	100	35.0	30.5	.61	139.9	1.38	1980	2360	128.8	1.28	11.1	.110	—	—	—	—
174	B-707	160.0	102.0	2.4	.80	380	-480	20.0	35.5	.71	135.7	1.33	1550	1930	134.6	1.32	1.1	.011	—	—	—	—
176	B-720	151.5	92.0	3.8	1.27	440	780	68.0	28.0	.56	133.3	1.45	1830	2270	124.9	1.36	8.4	.091	—	—	—	—
177	B-720	150.0	91.7	3.3	1.10	600	-40	13.0	14.5	.29	118.9	1.30	680	1280	117.3	1.28	1.6	.017	—	—	—	—
178	B-707	160.0	102.0	3.9	1.30	900	860	48.0	10.0	.20	136.8	1.34	620	1520	135.7	1.33	1.1	.011	—	—	—	—
179	DC-8	168.0	96.0	5.0	1.67	190	-140	22.0	33.0	.66	127.4	1.33	960	1150	120.0	1.25	7.0	.073	—	—	—	—
180	B-720	150.0	91.7	2.9	.97	470	70	29.0	25.5	.51	130.3	1.42	1546	2016	125.1	1.36	5.2	.057	—	—	—	—
181	DC-8	173.0	97.3	3.6	1.20	560	40	18.0	15.0	.30	117.0	1.20	1395	1955	115.7	1.19	1.3	.013	—	—	—	—
182	B-720	145.0	90.0	2.9	.97	600	-100	16.0	19.5	.39	126.3	1.40	848	1448	125.3	1.39	1.0	.011	—	—	—	—
183	B-720	145.8	90.4	3.5	1.17	450	340	43.5	27.5	.55	125.1	1.38	2268	2718	112.4	1.24	12.7	.140	—	—	—	—
184	DC-8	181.7	100.0	2.4	.80	940	840	46.0	26.0	.52	125.8	1.26	3070	4010	121.6	1.22	4.2	.042	592	3.63	—	—
185	B-707	157.0	101.0	3.1	1.03	800	400	29.0	16.0	.32	138.1-	1.37	2942	3742	124.4	1.23	13.7	.136	—	—	—	—
186	B-720	144.7	90.0	2.8	.93	800	340	28.0	16.0	.32	128.7	1.43	996	1796	124.4	1.38	4.3	.048	—	—	—	—
187	DC-8	169.4	97.7	3.0	1.00	700	-100	9.0	13.0	.26	135.3	1.38	1870	2570	124.7	1.28	10.6	.108	—	—	—	—
188	B-707	139.1	95.0	2.8	.93	680	50	21.0	19.0	.38	135.9	1.43	2013	2693	123.8	1.30	12.1	.127	—	—	—	—
189	B-707	143.0	96.7	2.5	.83	200	100	46.0	42.0	.84	132.9	1.37	2600	2800	121.9	1.26	11.0	.114	—	—	—	—
190	B-720	143.7	89.7	2.0	.67	1040	-200	7.0	13.0	.26	134.6	1.50	1410	2450	130.9	1.46	3.7	.041	—	—	—	—
191	DC-8	146.7	89.7	2.3	.77	1000	100	13.0	9.0	.18	117.0	1.30	1077	2077	112.3	1.25	4.7	.052	—	—	—	—
192	DC-8	153.6	94.7	3.3	1.10	500	60	25.0	22.0	.44	120.7	1.27	1088	1588	116.4	1.23	4.3	.045	—	—	—	—
193	B-707	138.0	95.0	2.8	.93	-120	-260	45.0	55.0	1.10	130.7	1.38	4170	4050	122.3	1.29	8.4	.088	—	—	—	—
194	B-707	135.7	94.4	3.1-	1.03	-230	-300	46.0	60.0	1.20	135.8	1.44	2330	2100	127.9	1.35	7.9	.084	—	—	—	—
195	DC-8	166.0	95.0	2.9	.97	350	80	37.5	34.0	.68	129.2	1.36	2270	2620	119.7	1.26	9.5	.100	—	—	—	—
196	B-720	148.0	91.0	2.6	.87	880	1000	54.5	24.0	.48	132.2	1.45	1353	2233	127.5	1.40	4.7	.052	—	—	—	—
197	B-720	148.0	91.0	3.1	1.03	860	440	28.0	12.0	.24	126.9	1.39	1458	2318	119.5	1.31	7.4	.091	—	—	—	—
198	B-720	141.0	88.7	3.4	1.13	640	380	36.0	18.0	.36	127.4	1.44	1708	2348	120.4	1.36	7.0	.079	—	—	—	—
199	DC-8	165.0	95.0	3.9	1.30	500	360	41.0	25.0	.50	131.0	1.38	2078	2578	122.6	1.29	8.4	.088	—	—	—	—

TABLE III - OBSERVED DATA AT DENVER - CONT'D

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle θ^o	Approach Angle Ratio $\frac{\theta^o}{3.0}$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold, (th) Height $\frac{Ft.}{50}$	Threshold, (th) Speed, V_{th} CAS (kts)	Threshold, (th) Speed, V_{th} $\frac{V_{th}}{V_s}$	Main Gear Touchdown, (td) Distance, ft. From (th)	Main Gear Touchdown, (td) Distance, ft. From 50'H	Main Gear Touchdown, (td) Speed, V_{td} CAS (kts)	Main Gear Touchdown, (td) Speed, V_{td} $\frac{V_{td}}{V_s}$	Bleedoff Speed V_B (kts)	Bleedoff Ratio $\frac{V_B}{V_s}$	Nose Wheel Down from Touchdown Dist. (Ft.)	Nose Wheel Down from Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
201	B-707	237.0	94.8	3.0	1.00	920	720	40.0	13.0	.26	125.3	1.32	1042	1962	121.1	1.28	4.2	.044	---	---	---	---
204	DC-8	147.0	89.7	3.2	1.07	610	-120	9.0	15.0	.30	118.1	1.32	1328	1938	115.0	1.28	3.1	.034	---	---	---	---
205	B-707	140.0	95.8	2.4	.80	730	-140	14.0	20.0	.40	127.6	1.33	2068	2798	116.5	1.22	11.1	.116	---	---	---	---
206	B-720	140.5	88.5	2.3	.77	750	100	24.0	20.0	.40	122.8	1.39	1300	2050	117.6	1.33	5.2	.059	---	---	---	---
207	B-720	141.0	88.7	2.5	.83	940	40	7.0	5.0	.10	123.7	1.39	1208	2148	119.0	1.34	4.7	.053	---	---	---	---
208	DC-8	171.0	96.8	3.6	1.20	530	220	32.0	22.0	.44	125.6	1.30	1450	1980	122.4	1.26	3.2	.033	---	---	---	---
209	DC-8	158.7	93.0	2.1	.70	870	-160	13.0	18.0	.36	121.2	1.30	1220	2090	117.1	1.26	4.1	.044	---	---	---	---
210	DC-8	167.0	95.5	2.8	.93	480	-280	16.0	27.0	.54	121.2	1.27	1317	1797	114.4	1.20	6.8	.071	---	---	---	---

TABLE IV _ OBSERVED DATA AT DALLAS

Landing No.	Airplane	Weight in 1000 lbs.	V_s Stall Speed CAS (kts)	Approach Angle θ^o	Approach Angle Ratio $\frac{\theta^o}{3.0}$	50' Point Distance to Threshold, (Ft.)	Flare-Point Dist. to Threshold (Feet)	Flare-Point Height (Feet)	Threshold, (th) Height Feet	Threshold, (th) Height $\frac{Ft.}{50}$	Threshold, (th) Speed, V_{th} CAS (kts)	Threshold, (th) Speed, $\frac{V_{th}}{V_s}$	Main Gear Touchdown, (td) Distance, ft. From (th)	Main Gear Touchdown, (td) Distance, ft. From 50'H	Main Gear Touchdown, (td) Speed, V_{td} CAS (kts)	Main Gear Touchdown, (td) $\frac{V_{td}}{V_s}$	Bleedoff Speed V_B (kts)	Bleedoff Ratio $\frac{V_B}{V_s}$	Nose Wheel Down from Touchdown Dist. (Ft.)	Nose Wheel Down from Touchdown Time (Sec.)	Spoilers Up from Touchdown Dist. (Ft.)	Spoilers Up from Touchdown Time (Sec.)
213	B-720	148.0	91.0	2.9	.96	740	400	33.0	18.0	.36	137.0	1.50	1083	1823	131.2	1.44	5.8	.064	356	1.66	—	—
214	B-707	140.0	97.0	1.5	.50	220	220	50.0	32.0	.64	137.5	1.42	1285	1505	134.1	1.38	3.4	.035	1037	4.59	—	—
215	B-707	158.0	103.0	2.3	.77	640	100	28.0	25.0	.50	143.3	1.39	1229	1869	134.3	1.30	9.0	.087	449	2.05	—	—
216	B-720	148.7	91.0	2.6	.87	340	-200	24.0	34.0	.68	142.8	1.57	2079	2419	123.8	1.36	19.0	.209	409	1.98	—	—
217	B-707	165.0	103.5	3.3	1.10	600	-170	14.0	22.0	.44	152.1	1.47	1545	2145	137.7	1.33	14.4	.139	—	—	—	—
218	B-720	151.0	92.0	2.9	.96	850	1300	64.0	11.0	.22	129.6	1.41	1435	2285	119.8	1.30	9.8	.107	—	—	—	—
219	B-707	155.0	102.0	2.4	.80	790	680	46.0	26.0	.52	152.0	1.49	2050	2830	142.2	1.39	9.8	.096	438	1.85	—	—
220	B-707	158.0	103.0	2.9	.96	900	1060	58.0	16.0	.32	147.0	1.43	805	1705	141.3	1.37	5.7	.055	628	2.74	1045	4.62
221	B-720	138.0	87.7	2.8	.93	845	340	26.0	14.0	.28	127.5	1.45	1130	1975	120.0	1.37	7.5	.086	643	3.25	1000	5.13
222	B-707	169.3	96.0	3.0	1.00	670	260	29.0	22.0	.44	150.5	1.57	2185	2855	129.9	1.35	20.6	.214	—	—	—	—
223	B-707	154.0	102.0	2.5	.83	660	50	24.0	22.0	.44	142.0	1.39	1505	2165	133.4	1.31	8.6	.084	400	1.87	805	3.86
224	B-720	152.8	92.6	2.0	.67	900	200	24.0	15.0	.30	131.5	1.42	1455	2255	122.8	1.33	8.7	.094	—	—	—	—
226	B-707	160.0	104.0	1.9	.63	1180	400	25.0	18.0	.36	145.6	1.40	1925	3105	131.2	1.26	14.4	.138	—	—	—	—
227	B-707	155.0	100.5	2.7	.90	860	260	22.0	14.0	.28	145.6	1.45	1340	2200	129.5	1.29	16.1	.160	380	1.77	1070	5.10
230	B-707	155.5	100.7	2.2	.73	780	240	30.0	23.0	.46	153.7	1.53	1430	2210	138.3	1.37	15.4	.153	480	2.16	—	—
231	B-720	165.4	96.6	1.9	.63	1200	200	16.0	11.0	.22	138.1	1.43	1165	2365	125.5	1.30	12.6	.130	370	1.72	720	3.43
232	B-707B	167.2	95.3	2.6	.87	910	180	18.0	14.0	.28	150.7	1.58	1750	2660	129.6	1.36	21.1	.221	775	3.68	—	—
234	B-720	148.0	91.0	2.5	.83	990	300	20.0	12.0	.24	128.3	1.41	735	1725	120.9	1.33	7.4	.081	1240	6.34	—	—
235	B-707	157.0	103.0	1.8	.60	1020	200	25.0	20.0	.40	146.9	1.43	2050	3070	131.9	1.28	15.0	.146	—	—	—	—
236	B-720	149.7	91.5	1.6	.53	1010	30	23.0	22.0	.44	150.5	1.64	1990	3000	129.8	1.42	20.7	.226	—	—	—	—
237	B-720	148.0	91.0	2.4	.80	1100	380	20.0	10.0	.20	131.2	1.44	1380	2480	120.2	1.32	11.0	.121	370	1.78	—	—
238	B-707	162.3	104.0	2.0	.67	1250	50	8.0	7.0	.14	142.1	1.37	375	1625	137.4	1.32	4.7	.045	—	—	—	—
239	B-707B	173.0	97.0	2.7	.90	700	320	33.0	23.0	.46	156.9	1.62	1760	2460	138.1	1.42	18.8	.194	410	1.77	—	—
240	B-720B	145.0	93.5	2.6	.87	840	40	14.0	13.0	.26	144.7	1.55	2185	3025	125.4	1.34	19.3	.206	—	—	—	—
241	B-707	158.0	103.0	2.5	.83	1005	340	21.0	12.0	.24	142.4	1.38	1460	2465	126.4	1.23	16.0	.155	420	1.79	740	3.35
242	B-707	165.0	102.4	2.5	.83	780	30	27.0	26.0	.52	153.7	1.50	1835	2615	135.9	1.33	17.8	.174	265	1.35	—	—
243	B-720B	158.0	98.0	3.2	1.07	430	160	35.0	30.0	.60	139.3	1.42	1890	2320	129.9	1.33	9.4	.096	—	—	660	3.09
244	B-707	165.0	92.0	2.2	.73	1330	500	19.0	11.0	.22	143.3	1.56	2275	3605	124.9	1.36	18.4	.200	560	2.64	—	—
245	B-720	146.0	90.4	2.2	.73	1060	50	12.0	11.0	.22	138.2	1.53	1175	2235	128.8	1.42	9.4	.104	425	1.93	—	—
246	B-720	165.0	96.5	2.4	.80	980	30	12.0	10.0	.20	137.9	1.43	415	1395	134.4	1.39	3.5	.036	605	2.67	—	—
247	B-720B	157.0	97.3	2.6	.87	1000	400	21.0	7.0	.14	143.5	1.47	1520	2520	131.0	1.35	12.5	.128	505	2.37	—	—
251	B-707	153.0	101.4	2.4	.80	750	430	37.0	26.0	.52	143.2	1.41	2350	3100	114.0	1.34	29.2	.288	—	—	—	—
252	B-707	163.0	103.0	2.0	.67	1200	130	8.0	6.0	.12	142.6	1.38	680	1880	134.1	1.30	8.5	.082	—	—	—	—